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CRREL REPORT 89-10

US Army Corps of Engineers
Cold Regions Research & Engineering Laboratory

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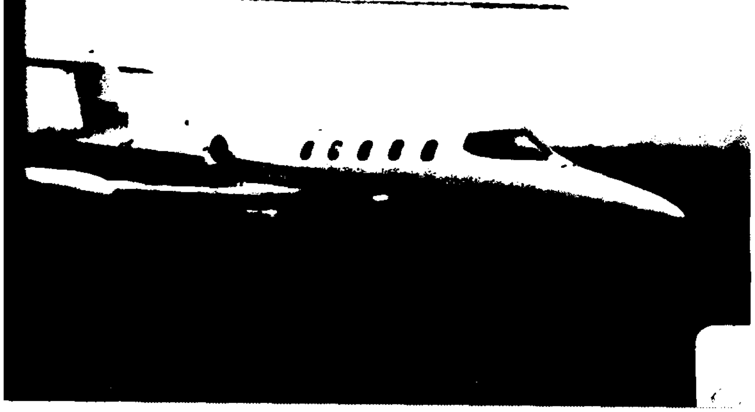
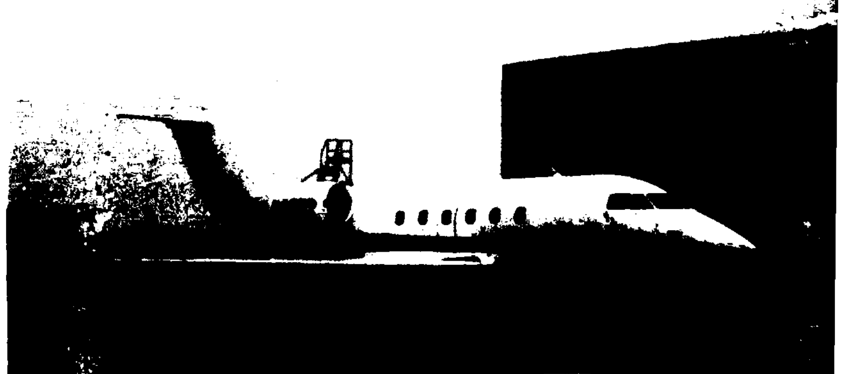
Definition of research needs to address airport pavement distress in cold regions





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For conversion of SI metric units to U.S./British customary units of measurement consult ASTM Standard E380, Metric Practice Guide, *published by the American Society for Testing and Materials, 1916 Race St., Philadelphia, Pa. 19103.*

Cover: Typical aircraft that use the airports described in this report. (Photos by C. Berini.)

Unclassified

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In early fall 1984, a questionnaire was sent to over 325 general aviation airports in cold regions. The results from over 200 responses were compiled and evaluated and over 20 airport managers were contacted for additional details. Site visits were made to 36 airports to obtain additional information. The most common pavement problems identified in the study were associated with non-traffic-related phenomena and include 1) pre-existing cracks reflecting through asphalt concrete overlays (in two years or less), 2) thermal cracking, and 3) longitudinal cracking (at a construction joint). Most of the airports experienced 1) water pumping up through cracks and joints in the pavements during spring thaw, or 2) additional roughness due to differential frost heave in the winter, or both problems. Many airport managers reported that debris was generated at cracks during the winter and spring. Many pavement problems can be traced to the evolutionary history of general aviation airports and the lack of consideration for site drainage. Based on the recognition of these problems, several future research programs are identified.

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PREFACE

This report was prepared by Ted S. Vinson, Professor, of Oregon State University (OSU); Dr. Richard L. Berg, Research Civil Engineer, of the Civil and Geotechnical Research Branch, Experimental Engineering Division, U.S. Army Cold Regions Research and Engineering Laboratory (CRREL); Irene Zomerman, formerly of CRREL and now with the Federal Aviation Administration (FAA), and Dr. Wilbur M. Haas, Professor, of Michigan Technological University.

The work associated with this report was funded by the U.S. Department of Transportation, Federal Aviation Administration, Washington, D.C., under Interagency Agreement DTFA01-84-Z-02038 with CRREL. Hisao Tomita, Project Manager, Aircraft Systems and Technology Branch, FAA, provided substantial guidance and assistance throughout the study, including participation in several airport site visits and technical review of the draft of this report. Robert Eaton of CRREL also technically reviewed the report manuscript. The senior author of the report participated in the work as a Battelle Summer Faculty Research Associate under a Scientific Services Agreement with Battelle Columbus Laboratories. William F. Quinn of CRREL provided valuable assistance and support to the senior author during the course of this work. The American Association of Airport Executives (AAAE) assisted substantially in this study through the assistance of its members. Fred Gammon was Chairperson of the Commuter/General Aviation Airports Committee during this study. Laurie Campbell, Peggy Offut, and Gail Mathieson Barnes provided valuable assistance in the preparation of the report. The Engineering Experiment Station, OSU, provided funding for the production of the manuscript of this report. The support provided by all of these organizations and individuals is sincerely appreciated and gratefully acknowledged.

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Definition of Research Needs to Address Airport Pavement Distress in Cold Regions

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INTRODUCTION

Statement of the problem

Over the past two decades a substantial research effort has been focused on problems unique to large national and international airports to ensure safe and dependable commercial air transport. Relatively little research effort, however, has been directed toward the problems of smaller airports, which have mostly general aviation aircraft operations with relatively few air carrier operations per day. Operation, performance, and maintenance problems at smaller airports are often most severe for those airports located in cold regions where 1) ice, snow, and slush can accumulate on the pavement surface, 2) differential movements in the pavement structure can result from frost heave, 3) thermal contraction of the pavement surface and/or ground can result in detrimental cracking, 4) severe loss of bearing capacity in the pavement structure may occur during thawing periods, and 5) accelerated degradation of the pavement can occur owing to freeze-thaw cycling and cold temperature effects.

Purpose and scope

In recognition of the need to develop a research program that focuses on performance and maintenance problems unique to smaller airports in cold regions, a study was undertaken by investigators at the U.S. Army Cold Regions Research and Engineering Laboratory (CRREL) for the Federal Aviation Administration (FAA). The specific purposes of the study were to identify 1) problems unique to airport pavement performance and maintenance in cold regions, and 2) prospective research programs to eliminate or minimize the problems identified.

The scope of activities undertaken in the study included 1) the development of a written survey questionnaire and analysis of the responses received from airport managers and maintenance personnel in the northern tier of the U.S., 2) telephone follow-up surveys for select airports, 3) site visits to representative airports, 4) telephone interviews with consulting engineers and researchers involved with pavement performance and maintenance in cold regions, and 5) a thorough review of the literature from the U.S. and Canada relating to airport pavement performance in cold regions.

BACKGROUND — THE PHYSICAL ENVIRONMENT AND AIRPORT PAVEMENTS

Physical environment of study area

The study area may be considered to be the tier of states in close proximity to or north of the 40° parallel. This group of states may be identified from Figure 1, which also shows the distribution of mean air temperatures in North America. The mean annual air temperature in the study area is approximately 5° to 10° C (40° to 50°F). Specifically excluded from the study area are airports underlain by permafrost. The study, therefore, focuses on an area of seasonal ground freezing only.

The study area may be characterized from a climatological standpoint in a number of ways. Air temperature is perhaps the most convenient. Figure 2 presents mean minimum and maximum

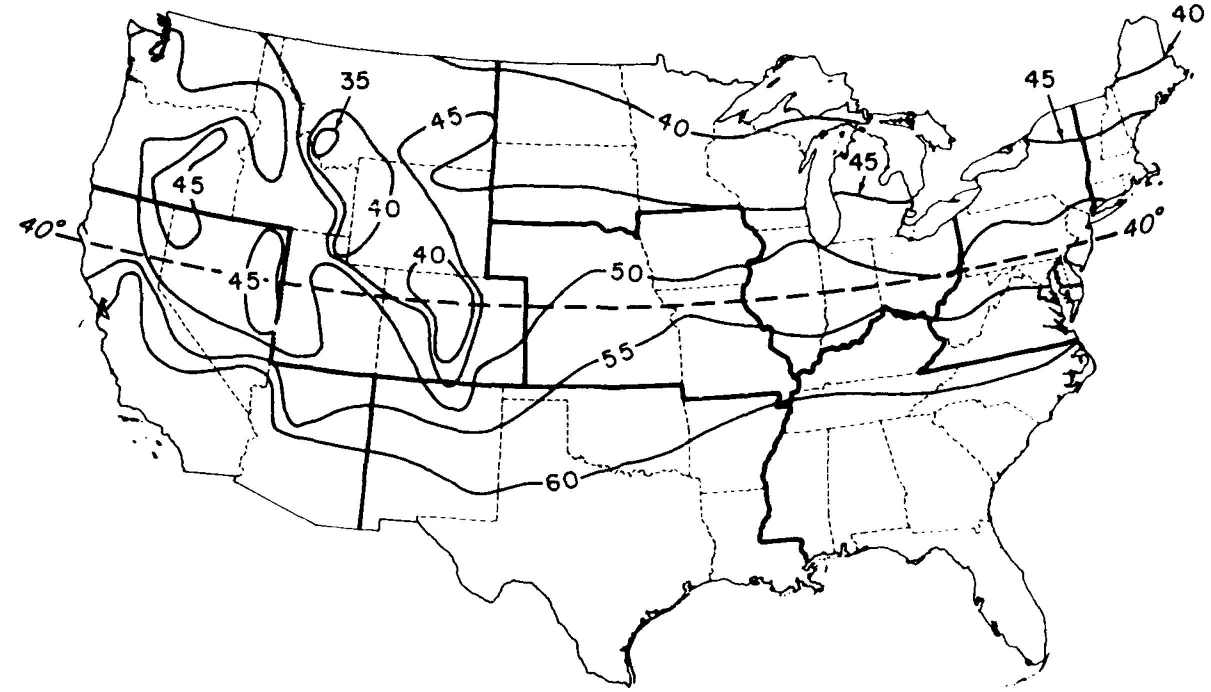
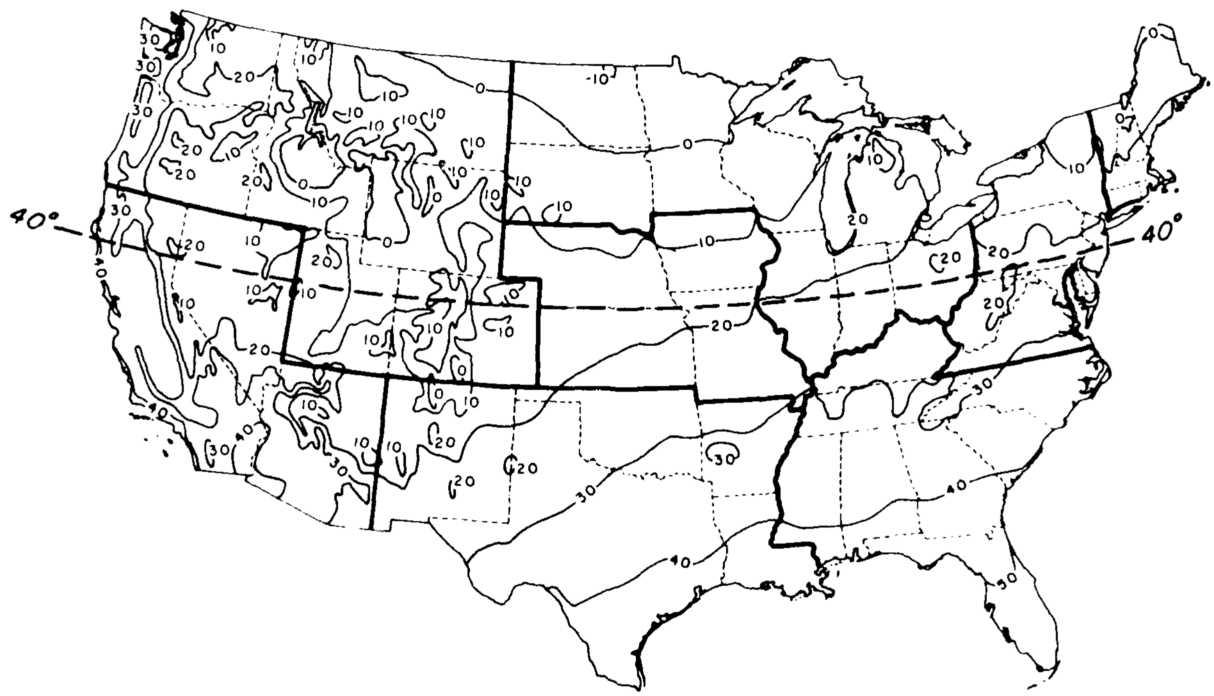
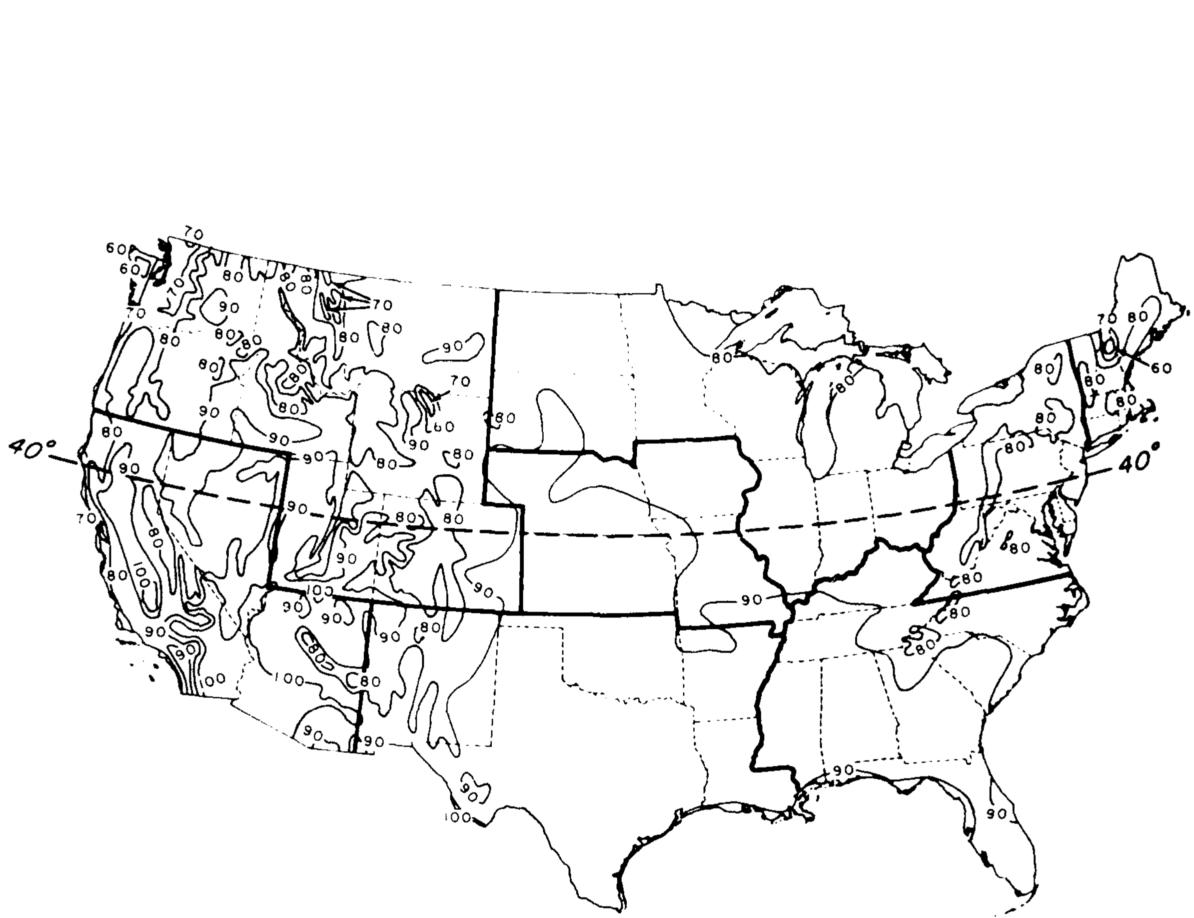


Figure 1. Mean annual air temperature (°F).



a. Normal daily minimum temperature (°F) in January.

Figure 2. Mean minimum and maximum air temperatures in the study area.



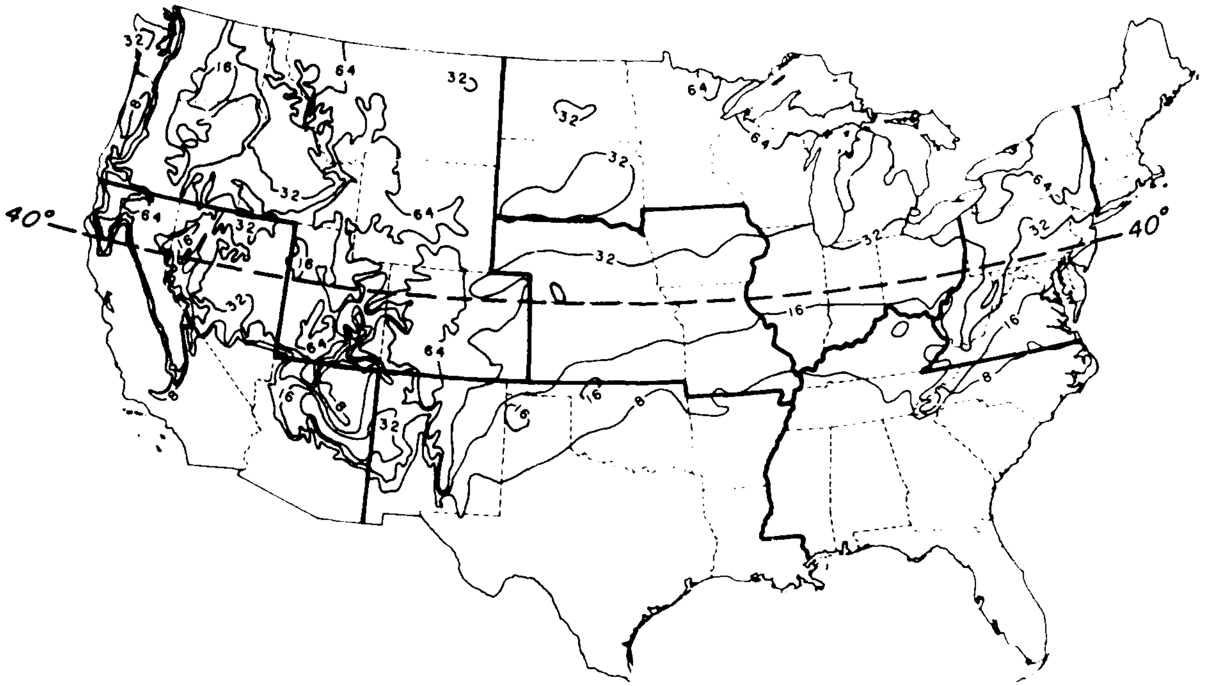
b. Normal daily maximum temperature (°F) in July.

Figure 2 (cont'd).

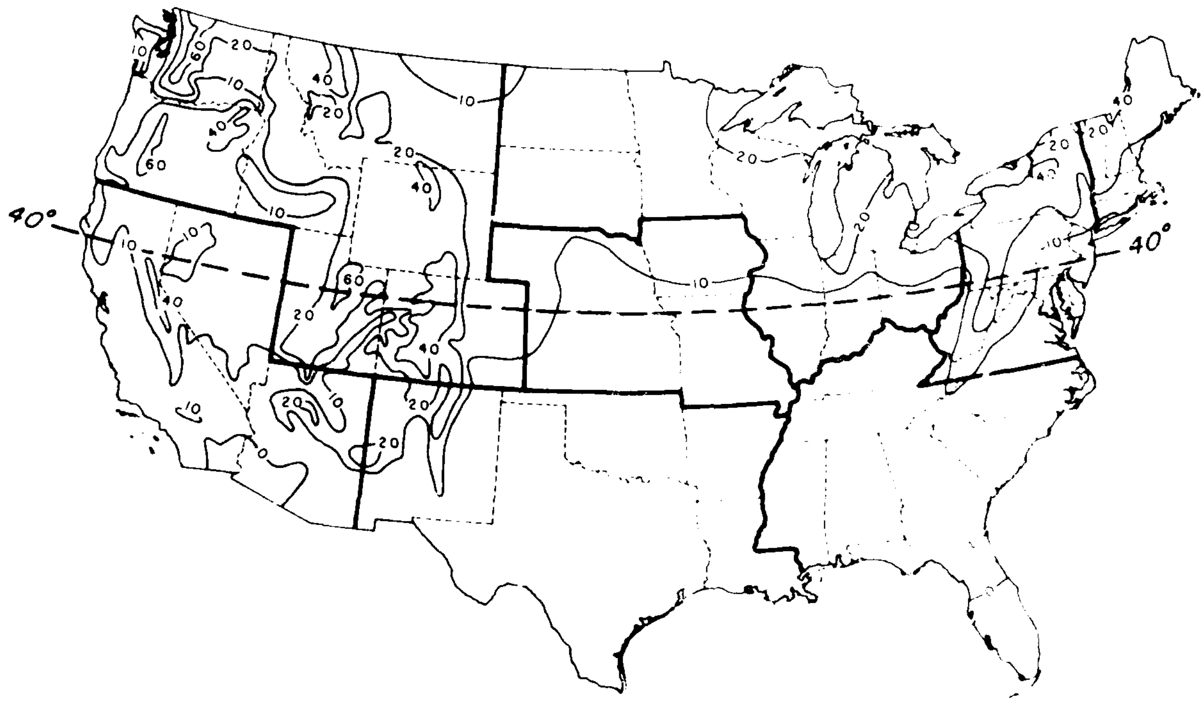
temperatures for the months of January and July, respectively, over the study area. Of interest is the range of temperature to which many parts of the study area are subjected. Mean temperatures may be as low as −18°C (0°F) in the winter and as high as 32°C (90°F) in the summer. Figure 3 presents snowfall data over the study area. In general, the mean annual snowfall is greater than 50 cm (20 in.) with 10 or more days of snowfall greater than 2.5 cm (1 in.). The information presented in Figures 2 and 3 suggests that ice and snow removal are of substantial concern to airport operations in the study area.

Figure 4 presents the distribution of mean air freezing indices over the study area. (The freezing index is a measure of the combined duration and magnitude of below-freezing temperatures occurring during any given freezing season; it is numerically equal to the cumulative negative degree-days for a given freezing season.) As may be noted, the mean air freezing index is more than 140°C-days (250°F-days) in the study area and can be an order of magnitude greater. The significance of this information is best understood by referring to Figure 5, which presents the relationship between depth of frost penetration in a pavement structure and air freezing index for various combinations of dry unit weight and moisture content of the subgrade soil. The frost penetration over the study area is of the order of 0.6 to 1.8 m (2 to 6 ft). Therefore, substantial depths of materials in the pavement structure are subjected to seasonal freeze and thaw.

Figure 6 shows the mean annual number of freeze-thaw cycles at several locations in the study area for an 18-year period. The range of freeze-thaw cycles is of the order of 40 to 120 cycles/yr. The upper end of the range of freeze-thaw cycles for the conterminous states is equivalent to that for many parts of Alaska as reported by Wexler (1983) (e.g. Fairbanks ≈ 80, Anchorage ≈ 100, Cordova ≈ 130 cycles/yr).



a. Mean annual snowfall (in.).



b. Mean annual number of days with snowfall 1 in. or more.

Figure 3. Snowfall data for the study area.

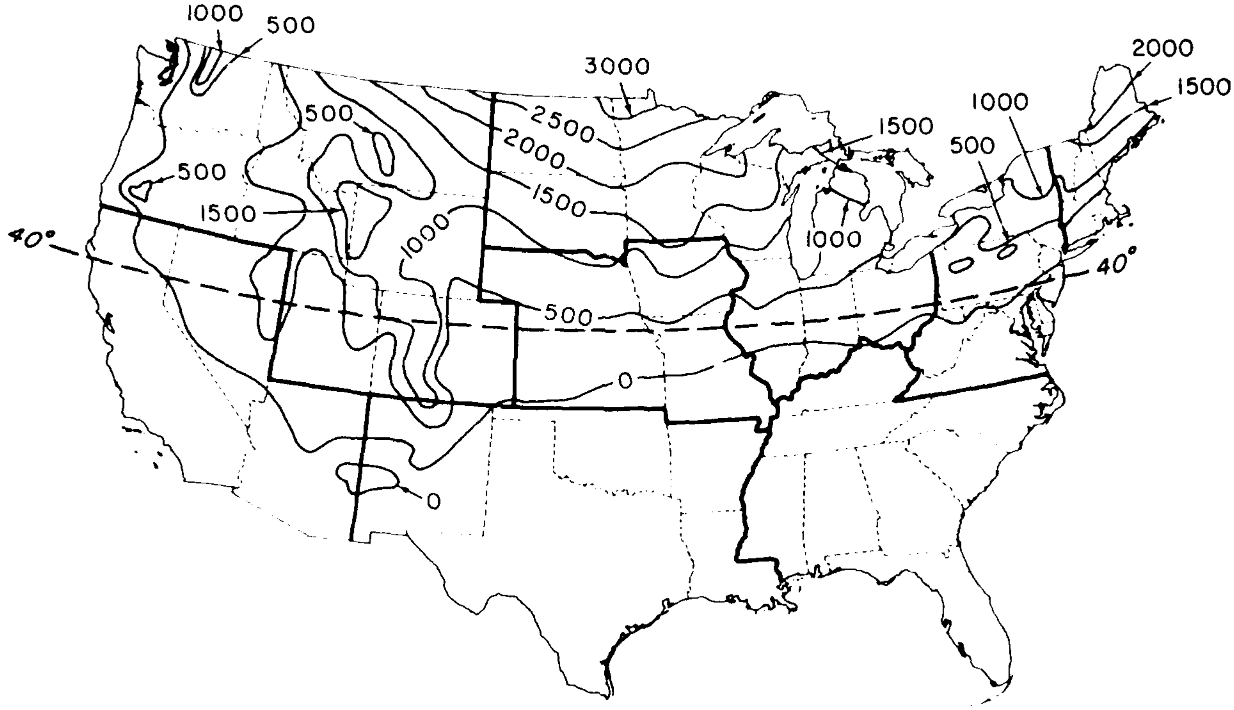


Figure 4. Distribution of mean air freezing indices in °F-days.

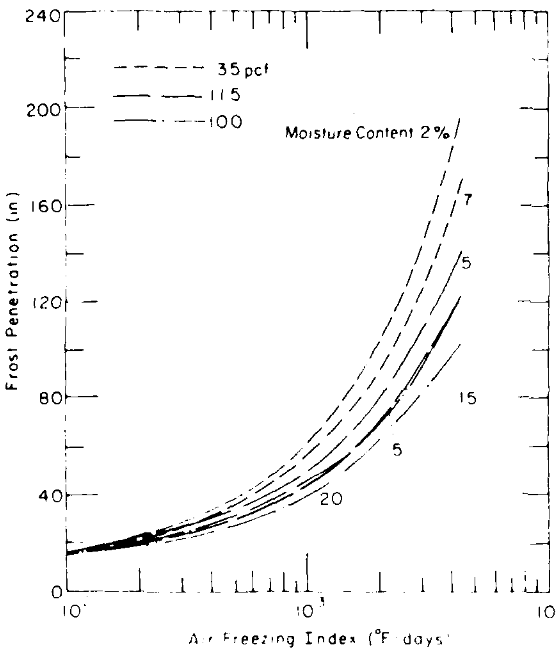


Figure 5. Depth of frost penetration vs air freezing index (modified after Berg and Johnson 1983).

Comparison of highway and general aviation airport pavements

Several factors distinguish highway and airport pavements. Perhaps the most obvious is the geometry, in plan, of the two pavements. Highway pavements are about 7 m (24 ft) in width with shoulder widths of 1.5 to 3 m (5 to 10 ft). General aviation airfield pavements may be 15 to 60 m (50 to 200 ft) in width, with lengths of about 1500 to 3000 m (5,000 to 10,000 ft). Taxiway widths vary from 6 to 30 m (20 to 100 ft). Surface drainage is almost always accommodated in airport pavements with a crown at the centerline; highway pavements may be crowned at the centerline, sloped downward toward the outside lane or, in some instances, level. Many highways are built with "trench" construction with no underdrainage except to ensure that the soils in the pavement structure are free draining. In some instances, subbase drains or a pervious layer extending through the shoulder is used to drain the pavement structure. Airfields are often built with subbase drains similar to those used for highways; to be effective, however, the subbase drains must be more closely spaced for airfields than for highways.

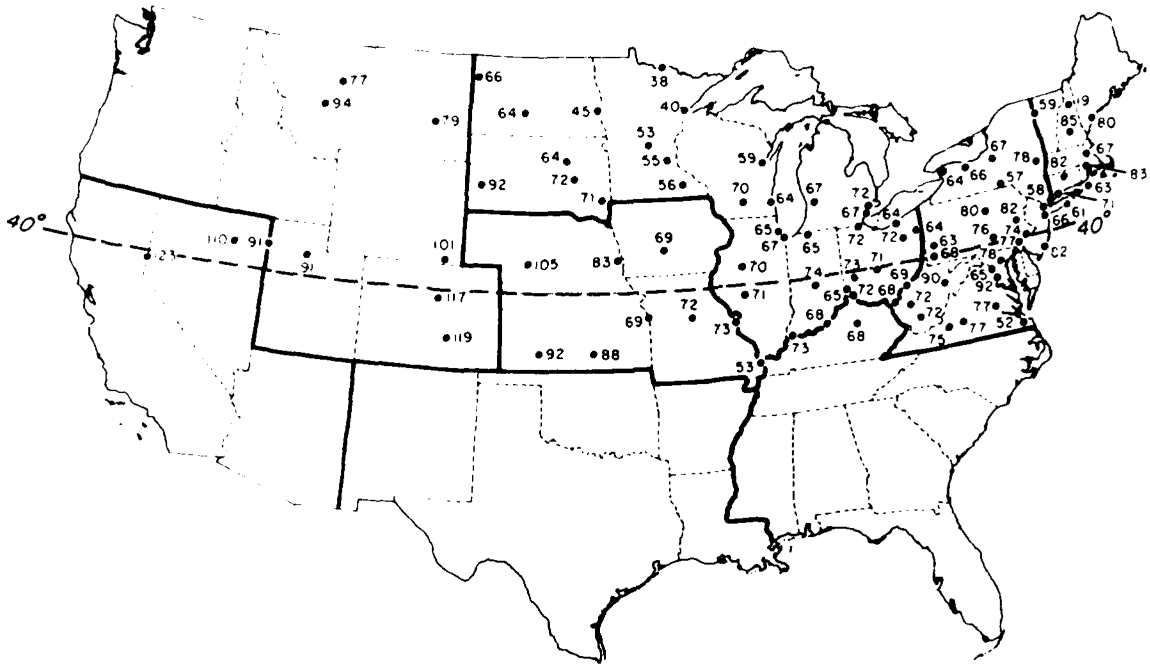


Figure 6. Mean annual number of daily freeze-thaw cycles based on air temperature for the period 1960—1978 (after Herschfield 1979).

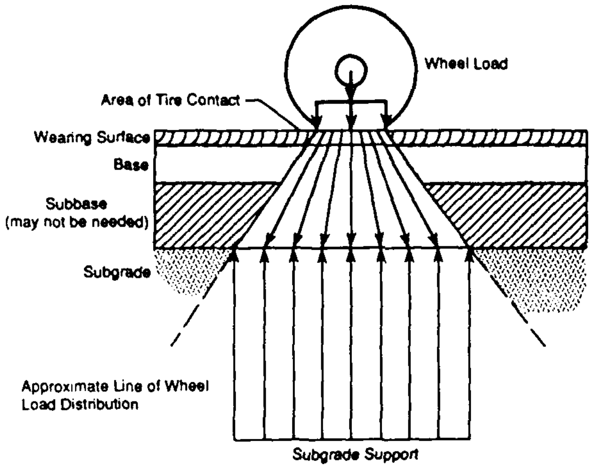
Traffic loading is substantially different for highway and airport pavements. Major highways have load repetitions of the order of 1,500 times per day with tire pressures of the order of 620 kPa (90 psi). General aviation airports, with infrequent commercial air transport service, may experience fewer than 10 heavy load repetitions with tire pressures of the order of 1 MPa (150 psi). Heavy traffic on highways is located from 0.9 to 1.2 m (3 to 4 ft) from the outside edge of the pavement, whereas airfield traffic is concentrated on and to either side of the pavement centerline.

The design load condition for airport pavements is associated with takeoff. Under this condition the gross weight of the plane with fuel is greatest. (During landing the fuel load is reduced and the airplane is partially airborne over much of the pavement structure.) Runway ends, taxiways, and aprons are often designed with a stronger pavement structural section to accommodate the concentration of slowly moving or stationary traffic in these areas.

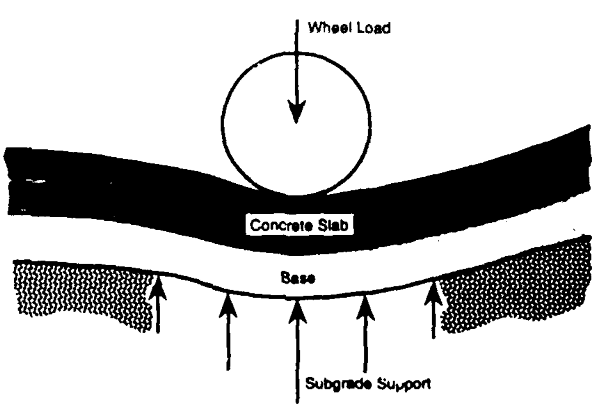
Perhaps the most significant factor that distinguishes smaller general aviation airports from highways, however, is the evolutionary development that most airports have experienced compared to the planned development that most highways experience. General aviation airports often start out very small and initially may be unsurfaced landing strips. Next, a surface is added, possibly with a base course layer for drainage. Parking aprons and taxiways are paved, extensions and widening of the main runway occur, and cross-wind runways are added, but all at different times and often without the concern for material quality that could be justified for many miles of a neighboring highway project. Further, general aviation airports are very often located in areas that are unsuitable for farming, generally because of poor drainage. Eventually as the area becomes paved, without due consideration for the drainage pattern in the vicinity of the airport, the lack of drainage beneath the pavement structure becomes all too obvious.

Types of pavements and surface treatments

Pavement structures are categorized by their load distribution characteristics. Rigid pavements distribute an applied load over a wide area and the structural capacity of the section is provided by the bending or flexural action of the wearing surface slab (Fig. 7a). Flexible pavements support applied load through bearing resistance (Fig. 7b). Flexible pavements are layered structures designed to ensure that the load transmitted to each layer does not exceed the load bearing capacity of the layer. Portland cement concrete (PCC) pavements are generally designed to be rigid structures, whereas asphalt concrete (AC) pavements are generally designed to be flexible structures.



a. Transfer of wheel load to foundation in rigid pavement structure.



b. Distribution of load stress in flexible pavement structure.

Figure 7. Load distribution characteristics for flexible and rigid pavements.

Pavement structures generally consist of a wearing surface and underlying base course, resting on an in-situ subgrade soil. Base courses are used to 1) provide drainage, 2) control frost action, 3) control pumping, 4) expedite construction (e.g. compaction of wearing surface), and 5) distribute the applied load (flexible pavement structure only; rigid pavements do not need a base course layer for load capacity). The thicknesses of the components in a flexible pavement structure are significantly influenced by the strength of the subgrade, whereas the thickness of a rigid pavement is influenced by the strength of the subgrade to a much lesser extent. The identification of an AC pavement as flexible may not be justified if 1) stabilized materials are used beneath the wearing surface, or 2) a thick AC surface layer is employed.

Pavement overlays are used to correct deteriorating pavement conditions (e.g. surface roughness, inadequate drainage, skid resistance, increase pavement strength). An overlay, strictly speaking, consists of one or more courses of AC or PCC material placed on an existing pavement. The overlay may include a leveling course to correct the contour of an old pavement, followed by a uniform course (or courses) to achieve the needed thickness. An overlay should not be confused with a reconstruction operation in which an old pavement structure is broken into relatively small pieces and removed (or mixed with the existing base course) and a new pavement structure (either AC or PCC is constructed).

Several types of surface treatments may be applied or added to existing AC pavements, as follows:

Seal Coat — a thin asphalt surface treatment used to waterproof and improve the texture of an asphalt wearing surface. Depending on the purpose, seal coats may or may not be covered with aggregate. The main types of seal coats are aggregate seals, emulsion slurry seals, fog seals, and sand seals.

Aggregate Seal — a single application of asphalt to any unpaved surface followed immediately by a single layer of aggregate of as uniform size as practicable. This is used as a wearing and waterproofing course.

Emulsion Slurry Seal — a mixture of slow-setting asphalt emulsion, fine aggregate and mineral filler, with water added to produce a slurry consistency. (An asphalt emulsion is a mixture of liquid asphalt and water that contains a small amount of emulsifying agent.) An emulsion slurry seal is used to fill minor cracks and rejuvenate the pavement surface.

Asphalt Fog (Black) Seal — a light (typically spray) application of liquid asphalt without mineral aggregate filler. Slow setting asphalt emulsion diluted with water is the preferred liquid asphalt.

Sand Seal — an application of asphaltic material covered with fine aggregate. It may be used to improve skid resistance of slippery pavements and prevent water intrusion.

Porous Friction Surface Course (PFC) — a mixture of an open-graded aggregate bound with asphalt used as a non-strengthening overlay. It is used to rapidly remove water from the pavement surface, thereby improving frictional resistance during periods of rainfall.

Surface Grooving — parallel saw cuts in the pavement surface. Used to rapidly remove water from the pavement surface during periods of heavy rainfall and improve frictional resistance.

Pavement distress and condition rating

Pavement distress may be broadly categorized by mode (Berg and Johnson 1983) as shown in Table 1. Further, pavement distress may be caused by traffic/load-associated phenomena or non-traffic-associated phenomena. Traffic/load-associated phenomena include excessive gross loads or tire pressures and/or a substantial number of load repetitions. Non-traffic-associated phenomena include frost action (heaving and thaw weakening), soil volume change under wetting and drying, breakup resulting from freezing and thawing of water in the wearing course, non-durable aggregates and aggregate stripping (the last three factors may be aggravated by the application of salts or antifreeze chemicals to the wearing surface). Poor or substandard construction, faulty workmanship, or unsuitable materials can accelerate pavement distress.

Cracking and distortion (often interrelated) are common indicators of pavement distress and create overall pavement roughness. Cracks may be longitudinal, transverse, diagonal, or may occur at the corners of slab sections in PCC pavements. A crack is distinguished from a spall in that the crack extends nearly vertically through or into the slab, while a spall intersects the slab edge at an angle and does not extend through the slab. "D" cracking, a pattern of cracks running in the vicinity of and parallel to a joint or linear crack, is unique to PCC slabs. It is believed to be caused by the concrete's inability to withstand volume change associated with freeze-thaw cycling or expansive aggregates.

Distortion is movement of the pavement surface resulting from frost heave, loss of fines or base course beneath the pavement (from pumping), intrusion of the fines into the base course, expansive/contractive soils, and, in PCC pavements, curling or buckling due to temperature or moisture changes. Differential movement that occurs over a short distance, such as across a crack, may require immediate attention. Uniform movement, even if large, usually does not present a major problem.

Distress, if not addressed, may cause disintegration, that is, the breaking of a pavement into small fragments, or dislodging of aggregate particles. Loss of skid resistance (the inability of a pavement to provide a surface with adequate frictional resistance for all environmental conditions) can also be considered a form of distress.

Of great concern to airport managers is the need to identify the state of deterioration and level of serviceability of their pavement structures. This concern is a direct consequence of their need to 1) maintain a safe facility, 2) schedule and perform routine maintenance operations, and 3) request funds for major reconstruction/rehabilitation projects at their airports. Many systems and techniques are available to rate pavement conditions at airports. In general, the rating systems or surveys consist of a visual inspection of the pavement surface that may or may not be supplemented with a device to measure pavement roughness, strength, or skid resistance. The FAA, in an attempt to apply a common rating system for 1) comparing the condition and performance of pavements at all airports and 2) providing a rational basis for justification of pavement rehabilitation projects, recommends that the Pavement Condition Index (PCI) be used (U.S. DOT 1982). The steps associated with determining the PCI are shown in Figure 8. Briefly, the airport pavement (runways, taxiways, parking aprons) must first be divided into features with common functions, structural sections, and overall construction history (step 1). Next, the pavement features are divided into sample units (step 2). A sample unit for a PCC

Table 1. Modes of distress in pavements (modified from Berg and Johnson 1983).

Distress mode	*General cause*	*Specific causative factor*
Cracking	Traffic load associated	Repeated loading (fatigue) Slippage (resulting from braking stresses)
	Non-traffic load	Thermal changes Moisture changes Shrinkage of underlying materials (reflection cracking, which may also be accelerated by traffic loading)
Distortion (may also lead to cracking)	Traffic load associated	Rutting, or pumping and faulting (from repetitive loading) Plastic flow or creep (from single or comparatively few excessive loads)
	Non-traffic load associated	Differential heave Swelling of expansive clays in subgrade Frost action in subgrades, subbases or bases Differential settlement Permanent, from long-term consolidation in subgrade Transient, from reconsolidation after heave (may be accelerated by traffic) Curling of rigid slabs, from moisture and temperature differentials
Disintegration	May be advanced stage of cracking mode of distress or may result from detrimental effects of certain materials contained within the layered system or from abrasion by traffic. May also be triggered by freeze-thaw effect.	
Inadequate skid resistance		Polished aggregate owing to traffic or rubber deposits building up over a period of time that reduce the frictional resistance of pavement

pavement consists of about 20 slabs, whereas a sample unit for an AC pavement consists of approximately 450 m^2 (5,000 ft^2) (an area 15 × 30 m [50 × 100 ft]), as illustrated in Figure 9. A minimum number of sample units must be surveyed to ensure an accurate estimate of the PCI. Figure 10 may be used to estimate the minimum number of sample units to be surveyed. The internal spacing of the sample unit may be computed from

$$i = \frac{N}{\eta} \quad (1)$$

where

i = spacing interval of units to be sampled

N = total number of sample units in the feature

η = number of sample units to be inspected (Fig. 10).

A visual inspection is made of each sample unit selected (step 3). A condition survey data sheet is used to identify the type and degree (severity) of distress found in each sample unit (Fig. 11). Distress densities and deduct values for a sample unit are determined, a total deduct value is computed and a corrected deduct value (CDV)

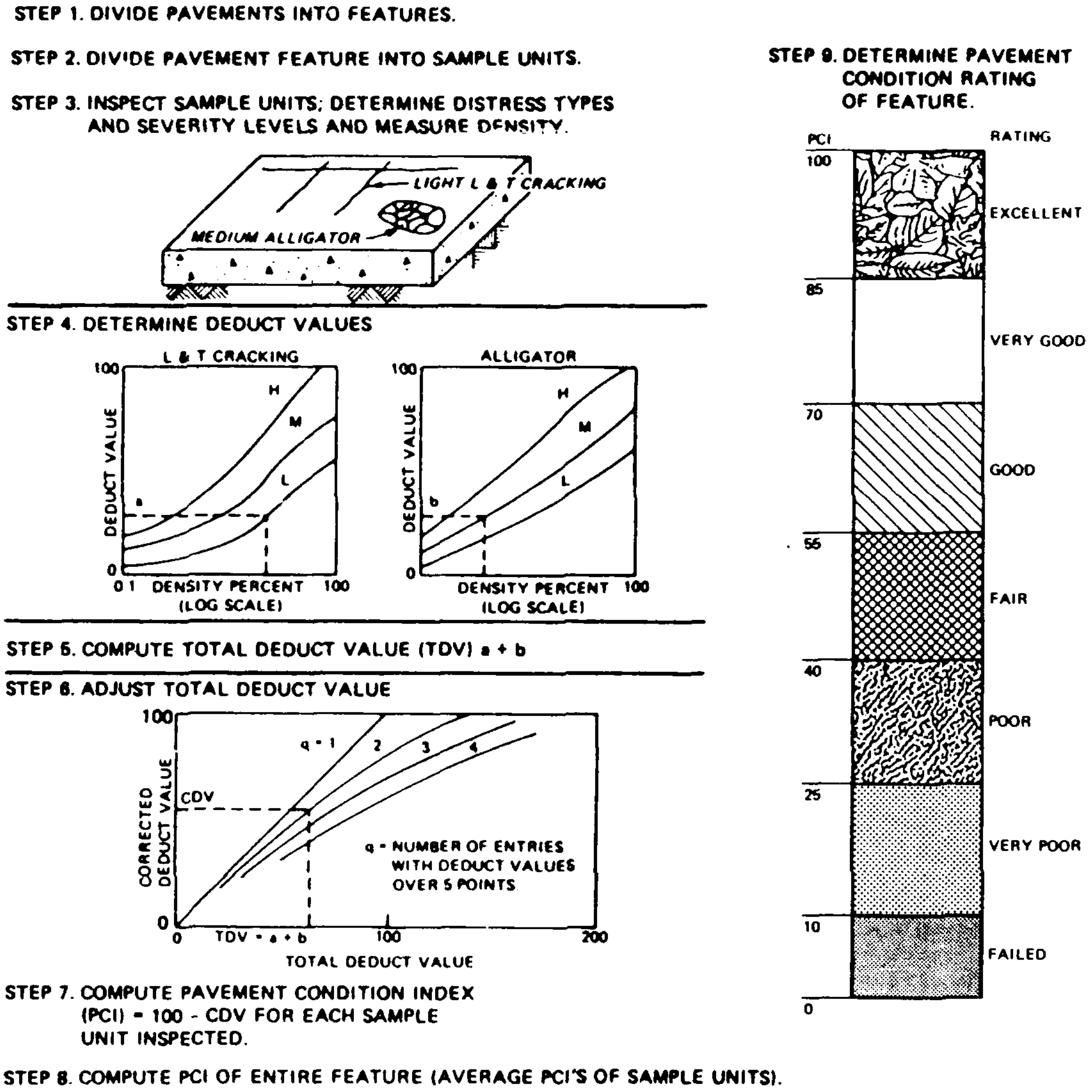


Figure 8. Steps for determining the PCI of a pavement feature (after FAA 1982).

is established following procedures given by Shahin and Kohn (1981) (steps 4, 5, and 6). The PCI for each sample unit may be calculated (step 7) from

$$PCI = (100 - CDV) \tag{2}$$

The PCI for the feature being considered is the average PCI for all sample units inspected (step 8). A verbal rating is established for the feature from the PCI (step 9). Figure 12 gives an example of final condition ratings for PCC and AC taxiways.

SURVEYS OF AIRPORT PAVEMENT DISTRESS

Problems associated with the operation, performance, and maintenance of airports located in cold regions were surveyed in three ways. First, survey questionnaires were sent to airport managers/executives in the 36 states in the study area. Second, telephone interviews of a number of airport managers who responded to the questionnaire were conducted. Finally, a number of airports were visited by one or more member(s) of the study team. The study team always included one or more of the authors and the air-

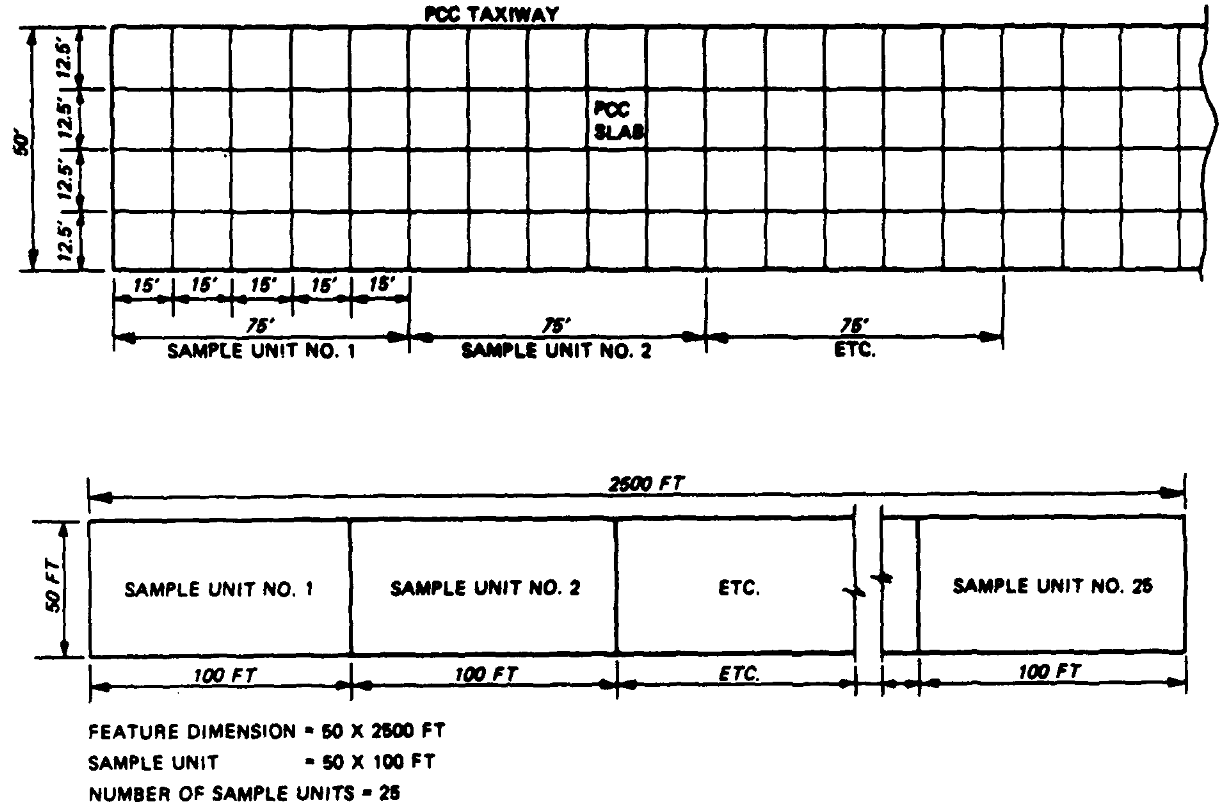


Figure 9. Division of pavement features into sample units (after FAA 1982).

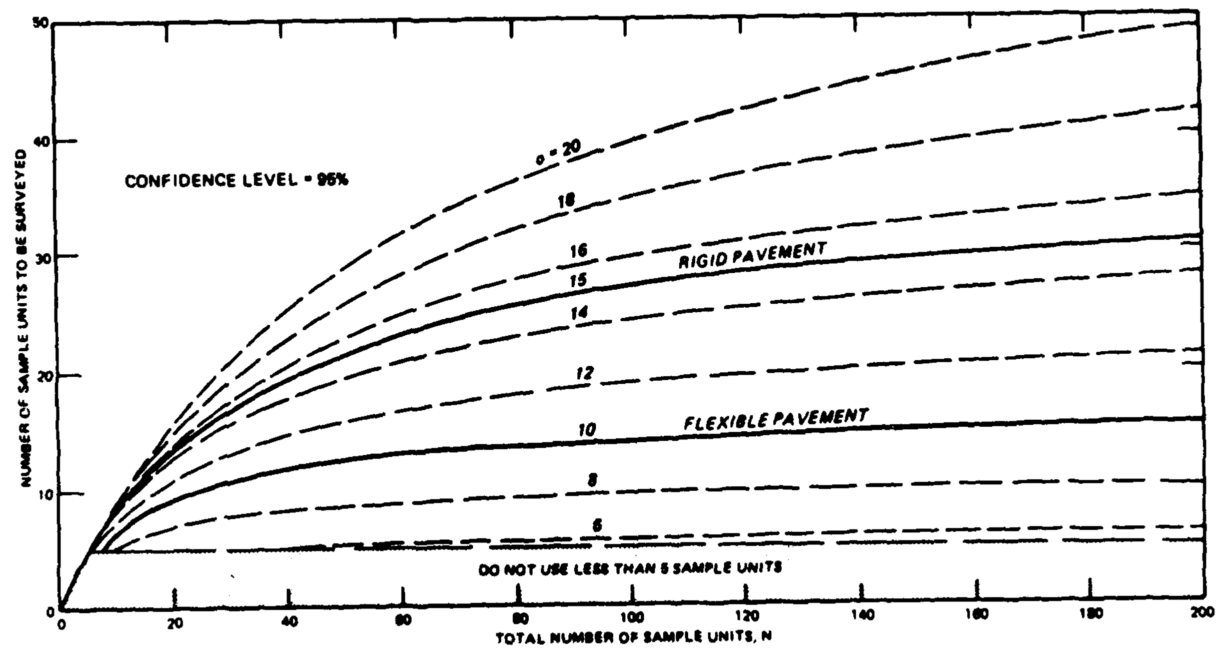
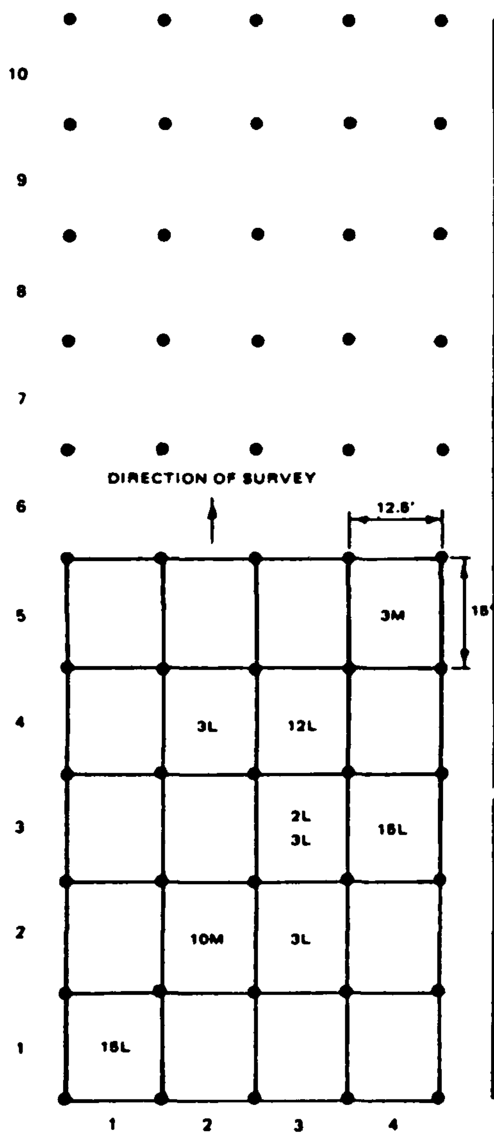


Figure 10. Selection of minimum number of sample units (after FAA 1982).

JOINTED RIGID PAVEMENT
CONDITION SURVEY DATA SHEET FOR SAMPLE UNIT

AIRPORT: WORLD INTERNATIONAL		DATE: 5/26/79
FACILITY: RWY 9-27	FEATURE: R3	SAMPLE UNIT: 12
SURVEYED BY: JH/DE		SLAB SIZE: 12.5 X 15 FT



DISTRESS TYPES

1. BLOW-UP
2. CORNER BREAK
3. LONGITUDINAL/ TRANSVERSE/ DIAGONAL CRACK
4. "D" CRACK
5. JOINT SEAL DAMAGE
6. PATCHING, <5 FT^2
7. PATCHING/ UTILITY CUT
8. POPOUTS
9. PUMPING
10. SCALING/MAP CRACK/CRAZING
11. SETTLEMENT/ FAULT
12. SHATTERED SLAB
13. SHRINKAGE CRACK
14. SPALLING — JOINTS
15. SPALLING — CORNER

DIST. TYPE	SEV.	NO. SLABS	DENSITY %	DEDUCT VALUE
2	L	1	5	4
3	L	3	15	11
3	M	1	5	11
10	M	1	5	7
12	L	1	5	10
15	L	2	10	3
DEDUCT TOTAL				46
CORRECTED DEDUCT VALUE (CDV)				32

PCI = 100 − CDV = 68

RATING = GOOD

Figure 11. Condition survey data sheets (after FAA 1982).

FLEXIBLE PAVEMENT
CONDITION SURVEY DATA SHEET FOR SAMPLE UNIT

AIRPORT: WORLD INTERNATIONAL	DATE: 5/26/79

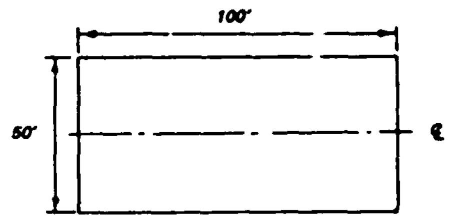
FACILITY: TXY E	FEATURE: T-11	SAMPLE UNIT: 4

SURVEYED BY: JH/DE	AREA OF SAMPLE: 5000 SQ FT

DISTRESS TYPES

1. ALLIGATOR CRACKING
2. BLEEDING
3. BLOCK CRACKING
4. CORRUGATION
5. DEPRESSION
6. JET BLAST
7. JT. REFLECTION (PCC)
8. LONG. & TRANS. CRACKING
9. OIL SPILLAGE
10. PATCHING
11. POLISHED AGGREGATE
12. RAVELING/WEATHERING
13. RUTTING
14. SHOVING FROM PCC
15. SLIPPAGE CRACKING
16. SWELL

SKETCH:



EXISTING DISTRESS TYPES

	1	5	8	12		
	4 X 4 M	6 X 4 L	10 L	3 X 10 M		
	2 X 3 L		5 L			
			15 L			
			5 M			
			10 L			
			5 M			
TOTAL SEVERITY L	6 SQ FT	24 SQ FT	40 FT			
TOTAL SEVERITY M	16 SQ FT		10 FT	30 SQ FT		
TOTAL SEVERITY H						

PCI CALCULATION

DISTRESS TYPE	SEVERITY	DENSITY %	DEDUCT VALUE
1	L	0.22	7
1	M	0.32	19
5	L	0.48	2
8	L	0.80	5
8	M	0.20	5
12	M	0.60	7
DEDUCT TOTAL			45
CORRECTED DEDUCT VALUE (CDV)			25

PCI = 100 − CDV = 75

RATING = VERY GOOD

Figure 11 (cont'd).

Airport: World International

Airport Facility: Taxiway 1

Total No. of Sample Units: 5

Date of Survey: 15 March 1979

Sample Unit No.	No. of Slabs	Slab Size	PCI
1	20	12.5 x 15	68
2	20	12.5 x 15	64
3	20	12.5 x 15	64
4	20	12.5 x 15	74
5	20	12.5 x 15	28

Sample Unit No.	No. of Slabs	Slab Size	PCI

Average PCI for Feature: 62

Condition Rating: Good

a. Feature summary — jointed rigid pavement.

Figure 12. Feature summary sheets and condition ratings (after FAA 1982).

Airport: World International

Airport Facility: Taxiway 5

Total No. of Sample Units: 25

Date of Survey: 26 March 1979

Sample Unit No.	Sample Unit Area, ft^2	PCI
1	5000	42
2	5000	33
3	5000	53
4	5000	39
5	5000	23
6	5000	25
7	5000	36
8	5000	38
9	5000	35
10	5000	25
11	5000	32
12	5000	45
13	5000	40
14	5000	55
15	5000	46
16	5000	35
17	5000	22
18	5000	30
19	5000	39
20	5000	35
21	5000	32
22	5000	41
23	5000	49
24	5000	30
25	5000	22

Average PCI for Feature: 35

Condition Rating: Poor

b. Feature summary for flexible pavements.

Figure 12 (cont'd).

port manager and/or maintenance supervisor. Further, for many of the airports, a local pavement consulting engineer, one or more pavement engineers from the FAA, and one or more state DOT pavement engineers joined the study team.

More than 350 questionnaires were mailed to airport managers/executives throughout the study area. These were sent under the cover letter shown in Appendix A, which identifies the cooperation of the American Association of Airport Executives (AAAE) in the study. Two-hundred and six responses were received. Response distribution with respect to FAA and AAAE regional boundaries is shown in Figure 13. The high degree of response is indicative of the excellent cooperation exhibited throughout the study by airport managers/executives, their consulting engineers, and AAAE members. In addition, the degree of response strongly suggests that the airport managers/executives welcome any study that might provide assistance to their pavement engineering and maintenance problems. Approximately 32% of the response was from the FAA Great Lakes Region, 20% (each) from the Northwest Mountain and Eastern Regions, 8% (each) from the Central and New England Regions, and the remaining 12% was spread among the Alaskan, Western Pacific, and Southern Regions. Figures 14–19 show each respondent's specific location by FAA region.

The survey questionnaire (App. A) was designed to reveal problems in the performance of airport pavements in areas of seasonal frost. Several questions were initially asked to provide a background for the study. The mix of aircraft types was very great and no generalization can be made. Aircraft ranging in size from Cessna 150s through Boeing 727s, 737s, and DC-9s were identified. The number of departures per week decreased substantially as the aircraft size increased, as would be expected. More than 60% of the airports surveyed anticipated that heavier aircraft would be using their facility in the next five years. Approximately 10% (of the 60%) identified Boeing 727/737s as the expected heavier aircraft and approximately 15% (of the 60%) identified Boeing 747s, 757s, or 767s.

Slightly more than 50% of the respondents have only asphalt concrete pavements in their

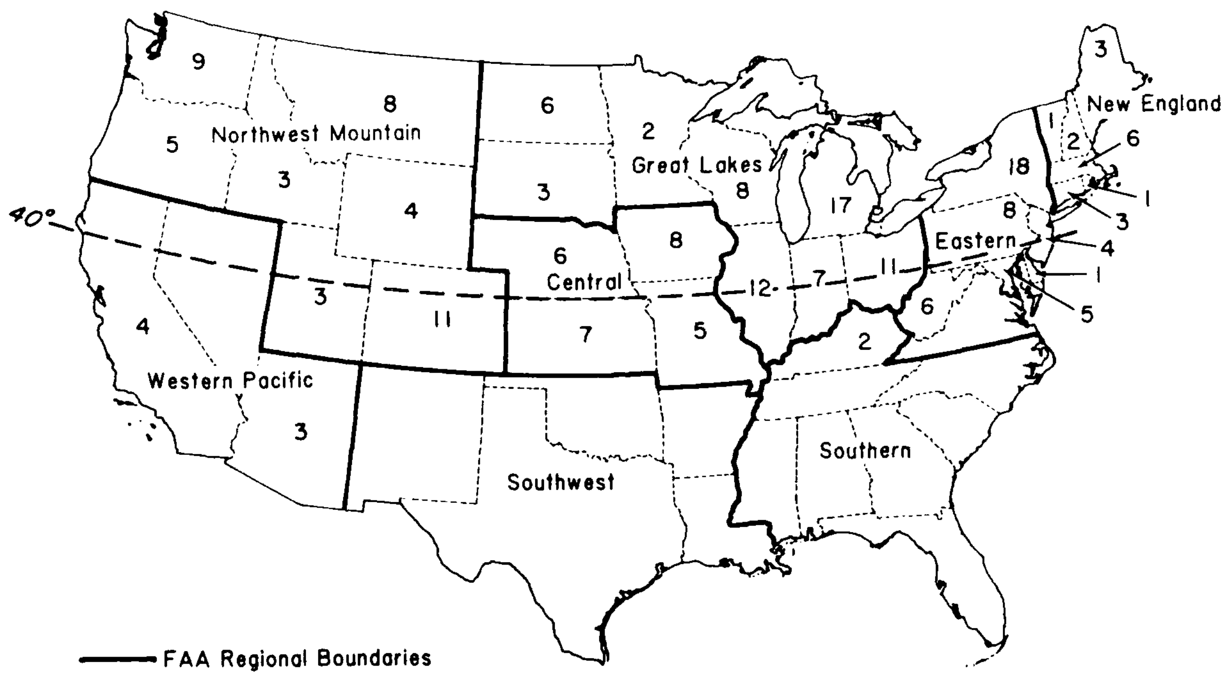


Figure 13. Distribution of survey questionnaire response with respect to FAA and AAAE boundaries.

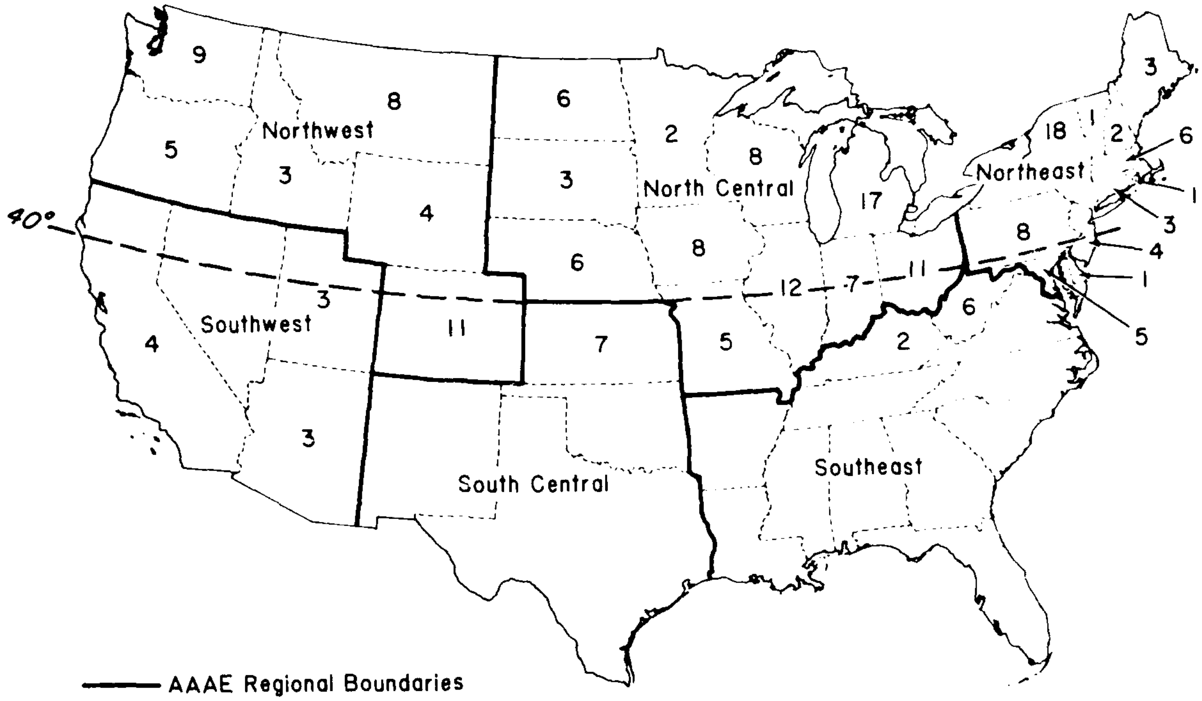


Figure 13 (cont'd).

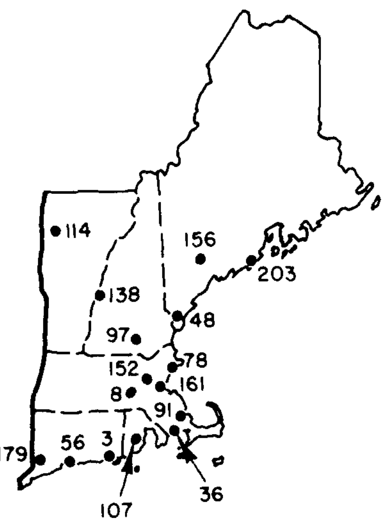


Figure 14. Location of respondents in the New England Region.

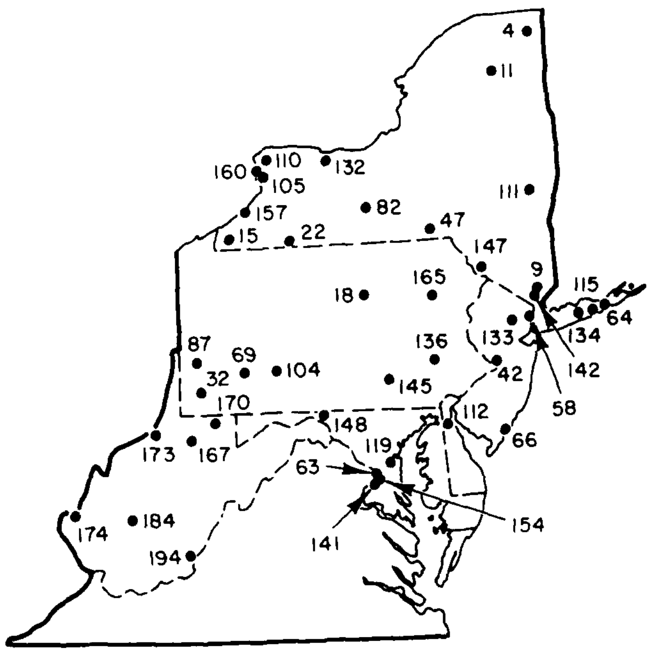


Figure 15. Location of respondents in the Eastern Region.

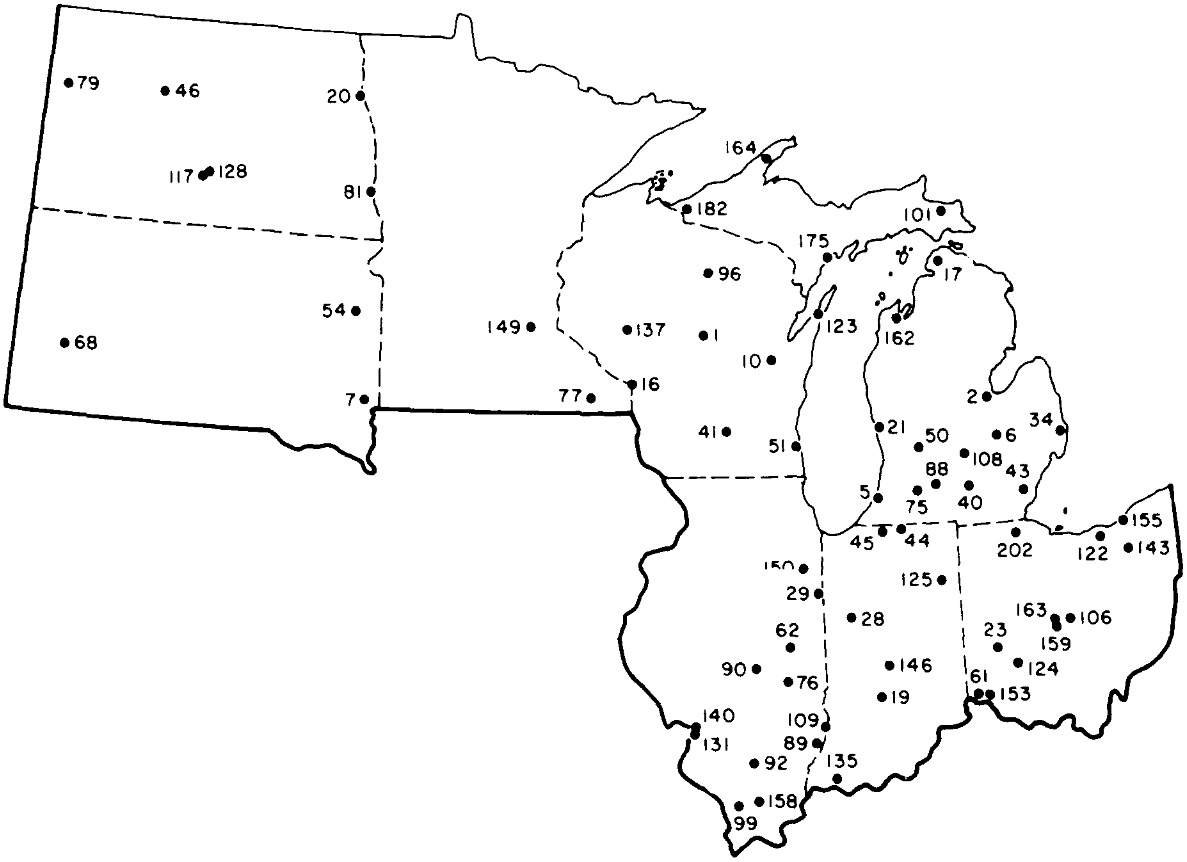


Figure 16. Location of respondents in the Great Lakes Region.

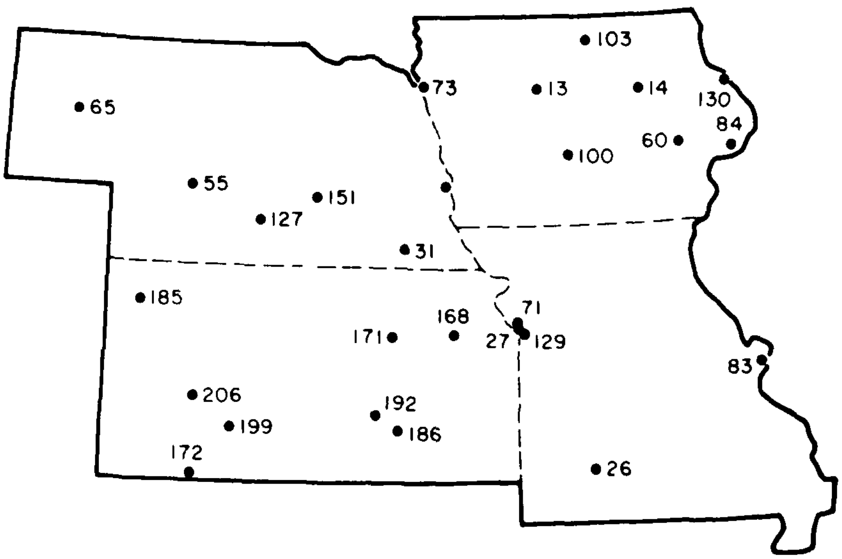


Figure 17. Location of respondents in the Central Region.

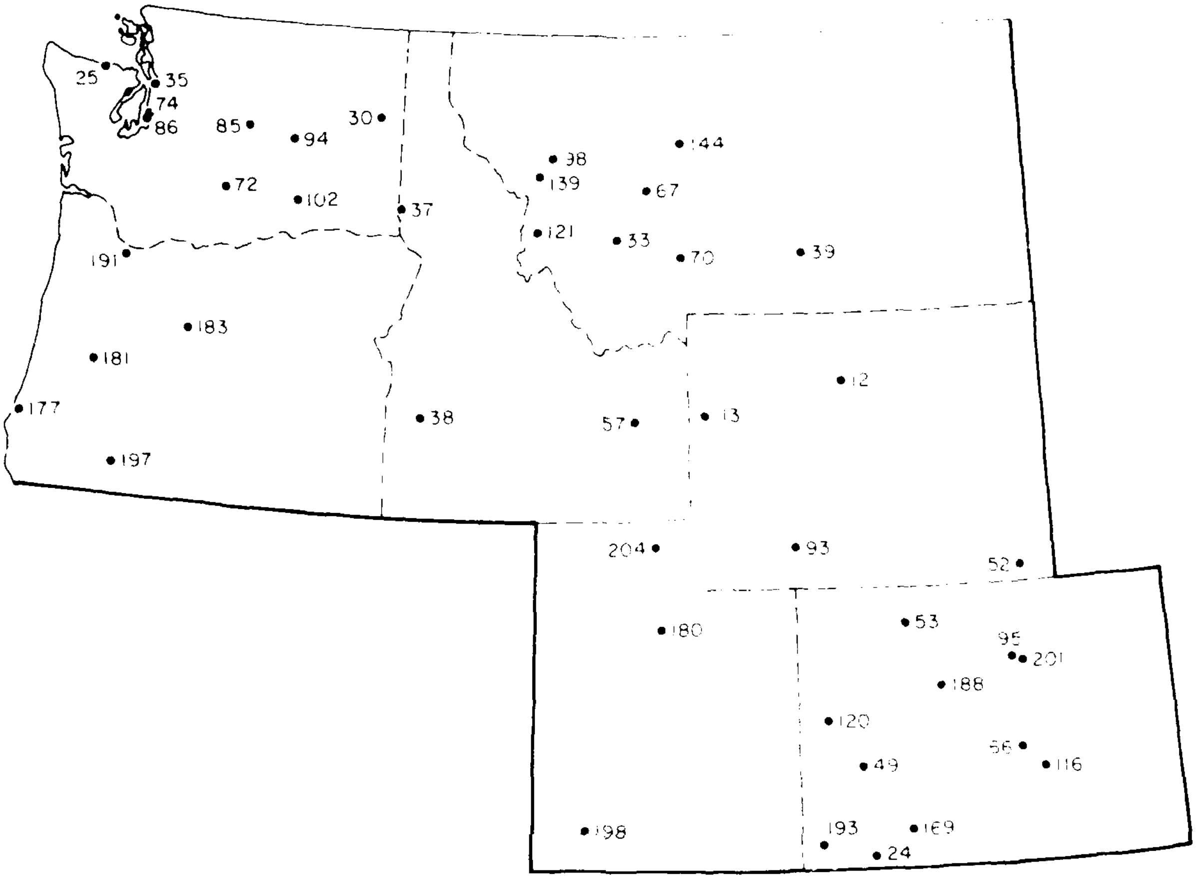


Figure 18. Location of respondents in the Northwest Mountain Region.

runways, taxiways, and parking aprons. Approximately 10% have only portland cement concrete and 40% have both types of pavement. This distribution of pavement types was fairly consistent for the regions with the greatest response (Eastern, Great Lakes, and Northwest Mountain), but Alaska and the Western Pacific response indicated that the majority of airports were constructed with asphalt concrete, whereas in the Central region the majority of the airports have portland cement concrete or both types of pavement. More than 80% of the airport managers/executives anticipated major reconstruction or new construction on their runways, taxiways, or parking aprons in the next five years.

The airport managers/executives were asked to qualitatively rate (i.e. excellent, good, fair, poor) the condition of their runways, taxiways, and parking areas. If one assumes that a fair or poor rating represents a marginal or unacceptable condition, 22% of the managers/executives indicated their runways were marginal, 21% indicated their taxiways were marginal, and 40% indicated their parking areas were marginal. Considering that a fair or poor rating in two or more pavement feature categories (e.g. runway, taxiway, or parking areas) indicates a need for reconstruction, 22% of the airport managers/executives will be involved in pavement projects in the near future.

The next series of questions on the survey was designed to reveal the degree of drainage, debris, and frost heave problems at the airports. More than 50% of the airports in the survey experienced water pumping upward through cracks or pavement joints. Forty-seven percent experienced[1] pumping during spring thaw, 34% after a heavy rain, and 28% under both conditions. Close to 60% of the airports in the survey had pavements that generated debris. Fifty-four

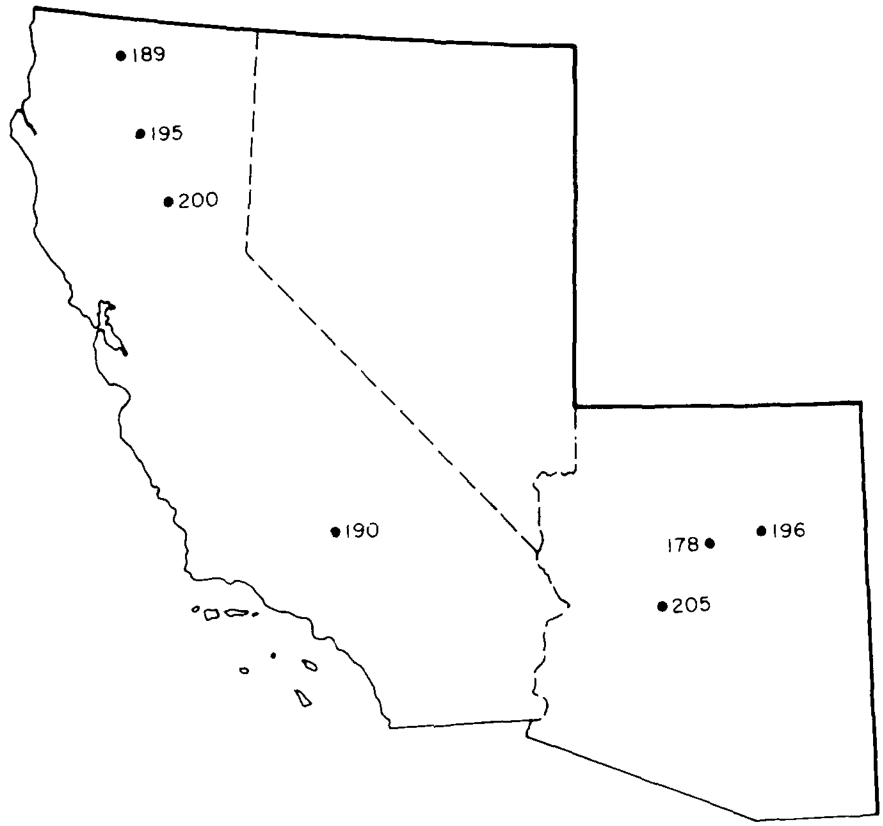


Figure 19. Location of respondents in the Western Pacific Region.

percent had debris generated during spring thaw and 35% under both conditions. Thirty-five percent of the airports in the survey indicated that they had rough pavements in late winter. (The roughness is attributed to differential frost heave.)

The data base developed in the study is stored in "dBase III" (Ashton-Tate). Consequently, a number of file sorts are possible to seek combination responses that might yield additional insights into pavement or maintenance problems. Table 2 summarizes several combination responses identified through file sorts performed by dBase III on the data set.

Approximately three-quarters of the airports in the survey have overlaid their pavements with asphalt concrete. Of those overlaid, 74% had most cracks reflected through the overlay in one or two years.

A written response of the most troublesome winter maintenance problem affecting aircraft safety (other than snow and ice removal) was solicited. Twenty-three percent of the airport managers/executives identified maintenance of lighting as a major problem; 21% identified debris cleanup, and 17% identified cold weather pavement movements (vertical differential and crack widening) as a major problem.

A summary listing of the questionnaire response including pavement type, surface rating, drainage, debris, roughness, and reflection cracking problems, and a statement of general problems encountered is given in Appendix B.

Telephone follow-up surveys were conducted to further determine the extent of the pavement performance problems. The airports were selected for the telephone survey based on the problems suggested in their response to the written survey questionnaire. In general, telephone interviews were made with the managers/executives at airports that had serious pavement problems and were considered for an on-site visit. The questions asked during the telephone interview are given in Appendix A.

Table 2. Responses from combination file sorts of data base.

Problem identified	Questionnaire response (%)	Overall response (%)	Central and Eastern (%)	Northwest, Mountain and Alaska
1. Drainage that generates debris during spring thaw and rainy periods	F.1. = yes F.2. = yes F.3. = yes F.4. = yes	19	22	9
2. Debris generated from cracks during thaw and roughness due to frost penetration	F.1. = yes G.1. = yes H. = yes	10	8	17
3. Subsurface drainage problems during rainy periods	F.2. = yes G.2. = yes	21	24	9
4. Subsurface drainage problems during spring thaw	F.1. = yes	34	39	24
5. Frost heave but no excess water during thaw	F.1. = yes H. = yes	10	13	4
6. Thaw weakening but no frost heave	F.1. or G.1. = yes H. = No	37	41	24
7. Thaw debris but no excess water during thaw	F.1. = yes	20	23	11

Note: *Response numbers refer to questions listed on questionnaire in Appendix A.*

On-site visits were made to 48 airports by one or more member(s) of the study team. A summary of the information gathered during the site visits is given in Appendix C. The on-site visits allowed the team members to obtain, first-hand, information on pavement distress at general aviation airports in cold regions. The problems revealed by these visits, together with a photographic record, are given in the next section.

AIRPORT PAVEMENT PEFORMANCE PROBLEMS IN COLD REGIONS

Pavement performance problems in cold regions may be categorized with respect to the modes of distress noted in Table 1, namely, 1) cracking, 2) distortion, 3) disintegration, and 4) inadequate skid resistance. Further, maintenance of airport pavements in cold regions must also be identified as a performance problem.

In the following discussion, an attempt is made to address the categories of problems noted above by presenting photographs of the problems revealed during the on-site visits to 48 airports. The examples are presented with a limited review of the current state of the art of research and/or practice in each problem area. The discussion of the problem areas is not exhaustive. The interested reader should consult the cited references for an in-depth treatment of the pavement performance problems considered.

Cracking

By far the most prevalent airport pavement performance problem is cracking. As noted in Table 1, cracking may be traffic/load-associated or non-traffic/load-associated. With respect to airport pavements, non-traffic/load-associated problems related to changes in temperature in the pavement structure and underlying ground are predominant. Figure 20 shows examples of transverse cracks in AC pavements caused by cold temperatures.

Three distress mechanisms are believed to cause thermal transverse cracking (Fromm and Phang 1972, Carpenter 1983). First, transverse cracks may be caused by the overall contraction of the entire pavement structure and/or underlying subgrade. This mechanism may cause the crack to extend through the entire pavement structure and into the subgrade. The crack can extend across the pavement surface into the shoulder and be several inches wide. This type of transverse crack is associated primarily with the thermal contraction of soil (in the base, subbase and/or subgrade) rather than the asphalt surface layer. Naturally, contraction of the surface layer also occurs with descending temperature.

The second and perhaps more common problem is associated with cracks occurring wholly in the AC surface layer. Specifically, low temperature fracture cracks can occur in the surface layer as it contracts and the tensile stress (caused by the contraction) exceeds the tensile strength. The problem is compounded at lower temperatures as stress relaxation tendencies for the AC decrease and material stiffness increases. Further, tensile strengths increase with descending temperature but only to some limiting value, whereupon they decrease. This fact, coupled with the increase in tensile stress, with descending temperature, suggests the mechanism of crack formation shown in Figure 21. The relationships between tensile strength or thermal stress and temperature depend on physical properties of the AC mixture (e.g. cement type, aggregate, filler, additives, and so forth) as shown in Figure 22. Also, the age of the AC and the rate of temperature change influence the relationships shown. The interaction between all these variables is extremely complex and it may be difficult to create a unifying theory to fully describe the failure mechanism.

The initial spacing of thermal fracture cracks depends on the geometry, in plan, of the pavement and the restraint provided beneath the AC layer. Transverse cracks generally appear initially at large intervals, typically greater than 30 m (100 ft). With the formation of the initial set of cracks, the geometry is effectively changed. Additional cracks that occur are generally associat-

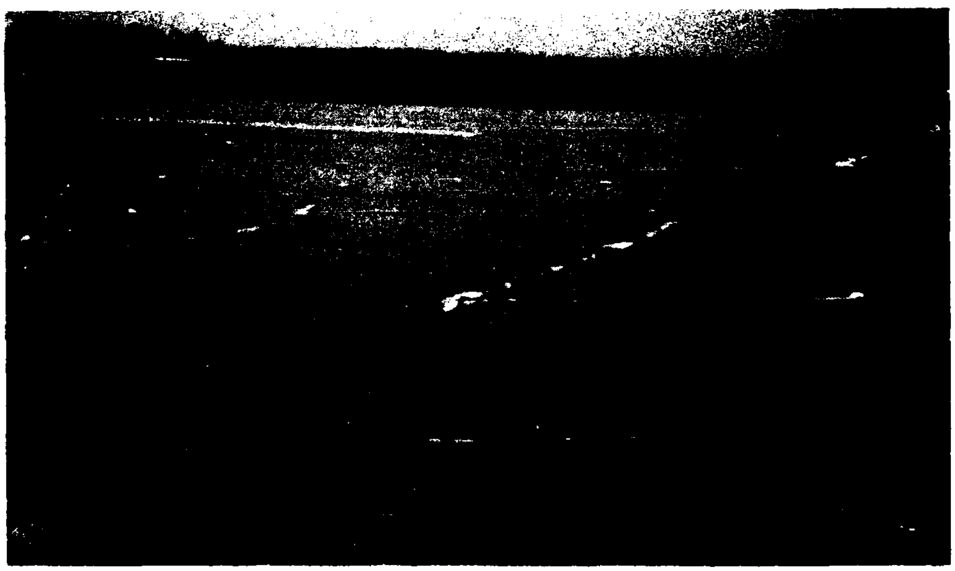


Figure 20. Transverse cracks in AC pavements caused by low temperatures.

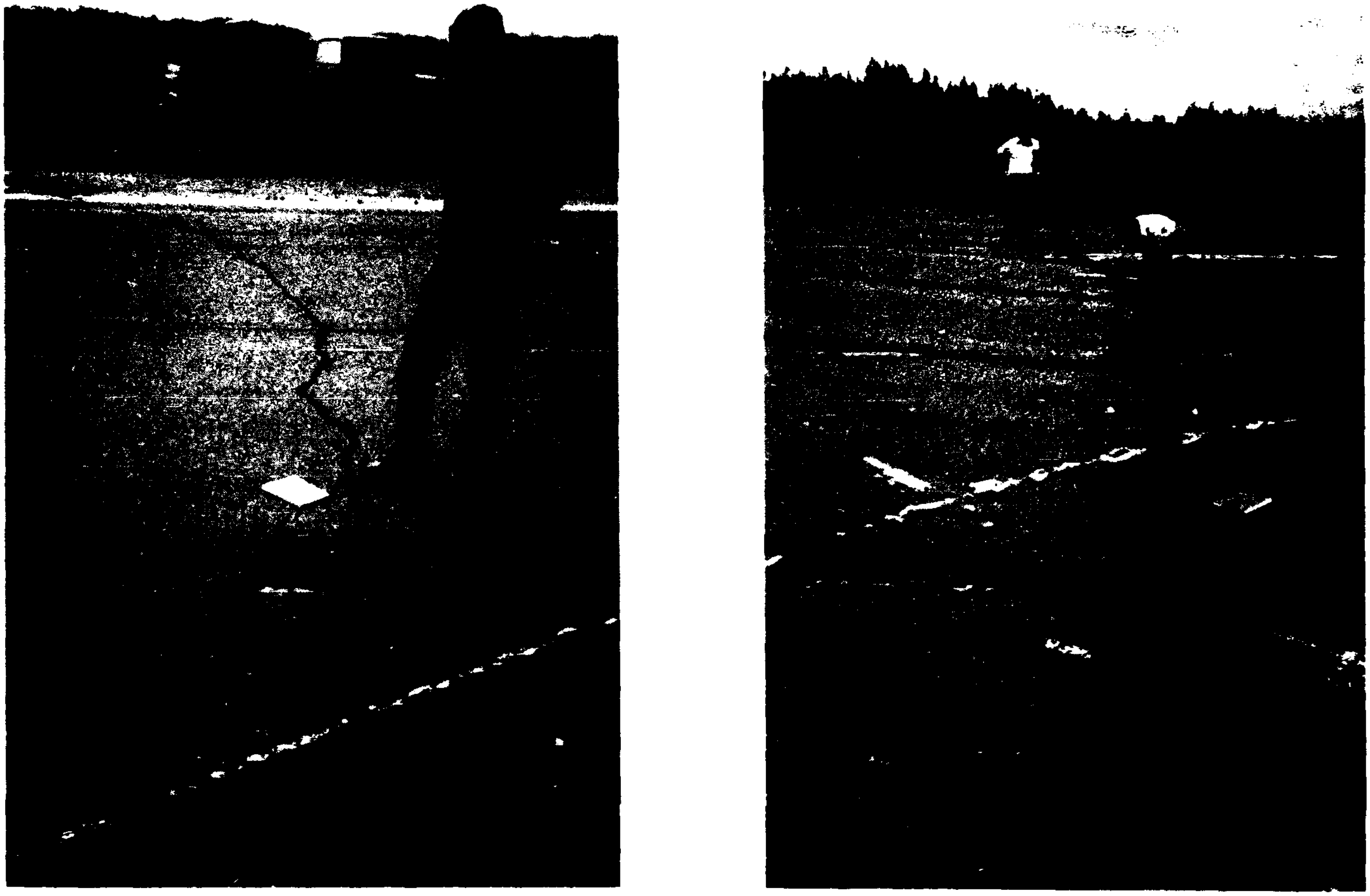


Figure 20 (cont'd).

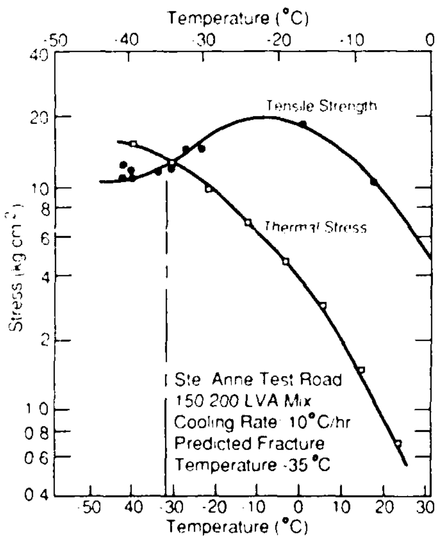


Figure 21. Variation in tensile strength and tensile stress as a function of temperature, indicating when fracture occurs (after Christison 1972).

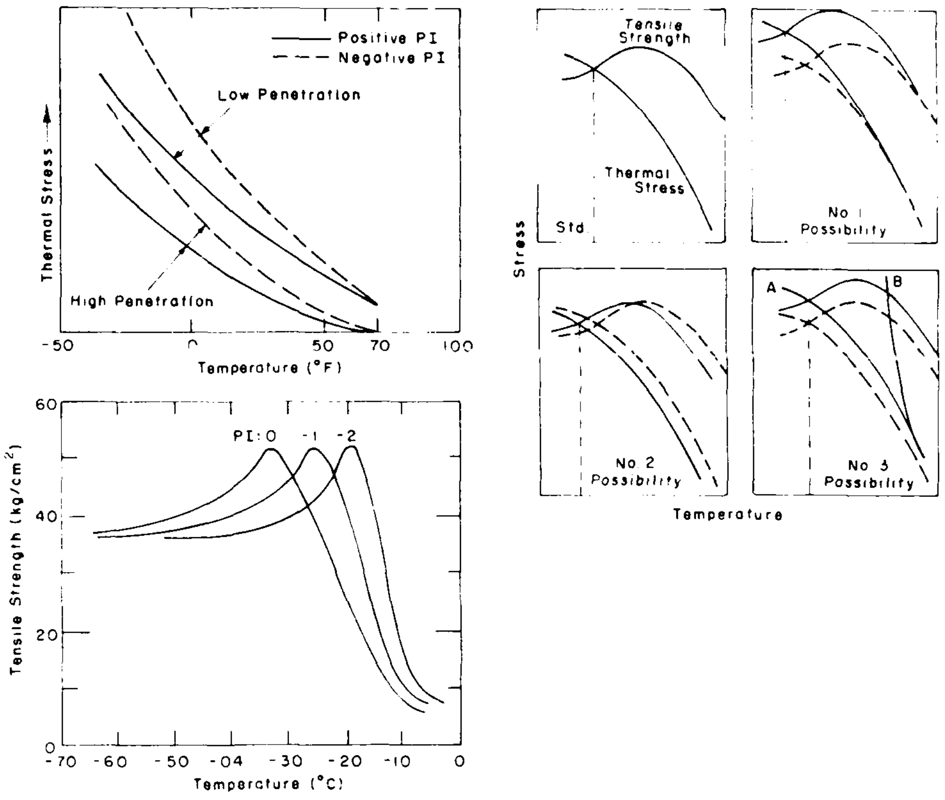


Figure 22. Schematic diagram indicating possible changes in the fracture temperature for changes in strength and stiffness.

ed with 1) lower temperatures, or 2) the fact that the asphalt cement hardens with age and changes the properties of the surface layer. With time, the crack spacing may decrease substantially and eventually create a complex pattern of transverse cracks exemplified in Figure 23.

The third mechanism of transverse cracking is associated with thermal fatigue. Daily temperature fluctuations (warm during the day, cold at night) produce cycles of tensile stress which, over time, cause fatigue failure in the AC. The mechanism is mostly likely to cause failure in regions which experience the greatest daily temperature extremes. As the asphalt hardens with age, thermal fatigue failure associated with daily temperature cycling can result in interconnected cracks that divide the pavement into approximately rectangular pieces as shown for the very old pavement in Figure 24.

Recognizing that thermal fracture and fatigue cracks are related to asphalt cement type, several government agencies have created material specifications to minimize temperature susceptibility (Ontario Department of Highways 1970, U.S. Army 1976, McLeod 1984, Carpenter and VanDam, 1985). The basis of the specification is the penetration viscosity number (PVN) of the asphalt cement, a parameter that influences temperature susceptibility. The grade of the asphalt cement controls the level of stiffness (at the grading temperature) but does not change the temperature susceptibility. Longitudinal cracks in AC pavements were observed at many airports. Examples are shown in Figure 25. Longitudinal cracks may be caused by 1) contraction of the AC due to age hardening of the asphalt or low temperatures (resulting in an approximately linear crack of finite length), and 2) an improperly constructed paving lane joint (resulting in a long, linear crack). Longitudinal cracks associated with both mechanisms were observed during the field visits.

Traffic/load-associated cracking in airport pavements was not common. Two examples are shown in Figure 26. Figure 26a shows cracks at the edge of pavement associated with snow

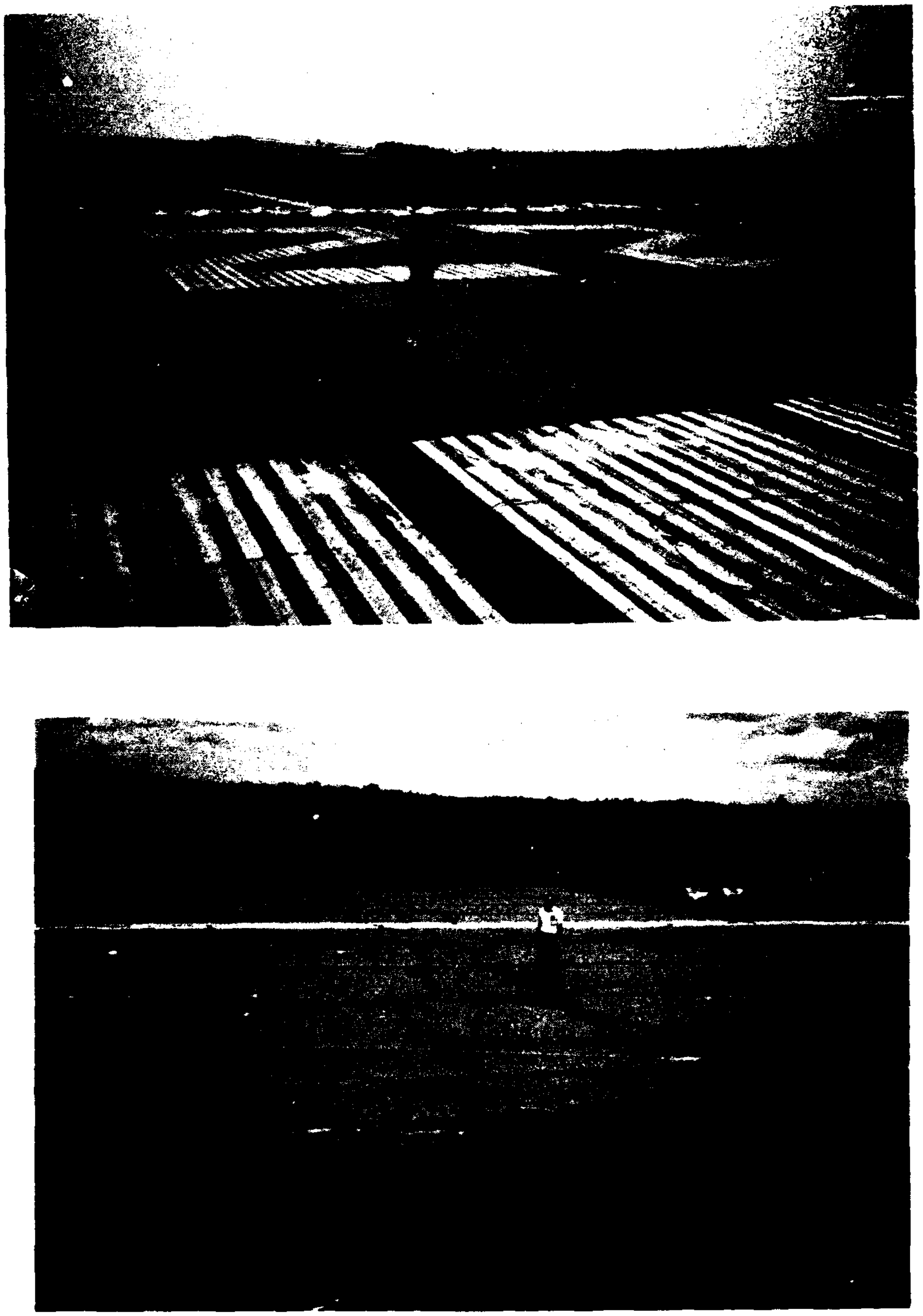


Figure 23. Decrease in crack spacing and increase in complexity of transverse crack spacing.

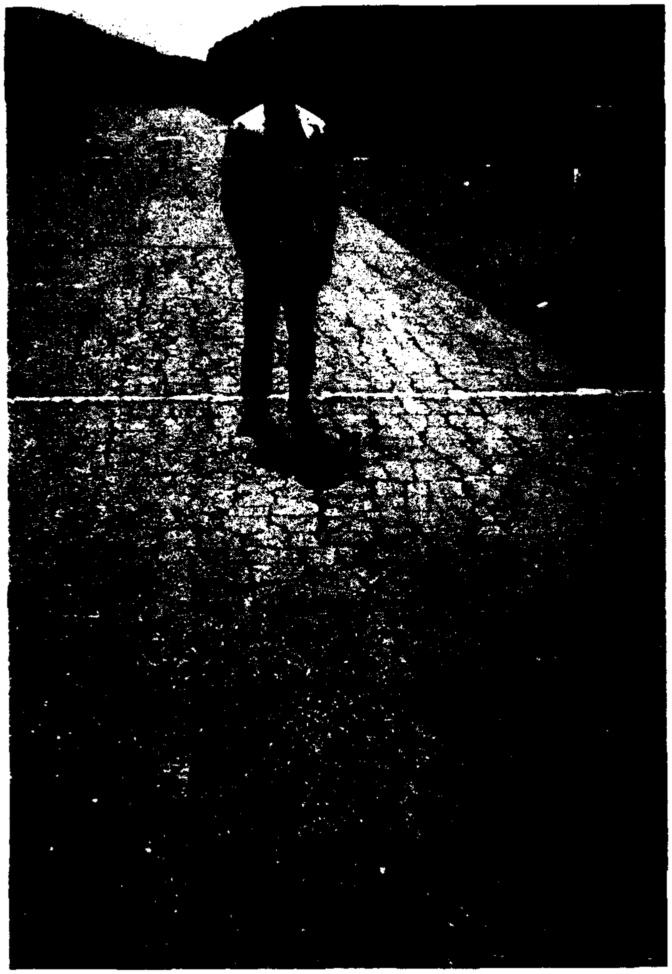


Figure 24. Thermal fatigue cracking.

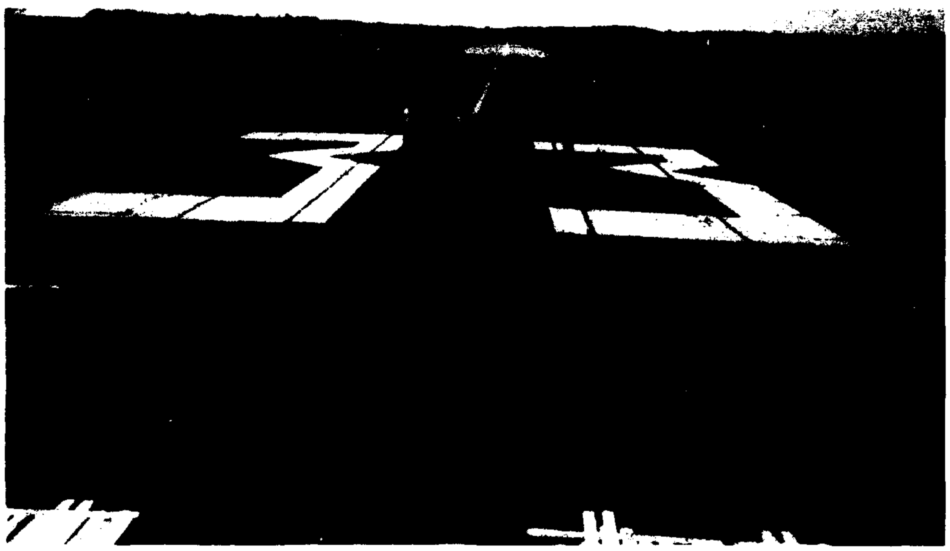


Figure 25. Longitudinal cracks associated with contraction of AC and/or improperly constructed lane joint.

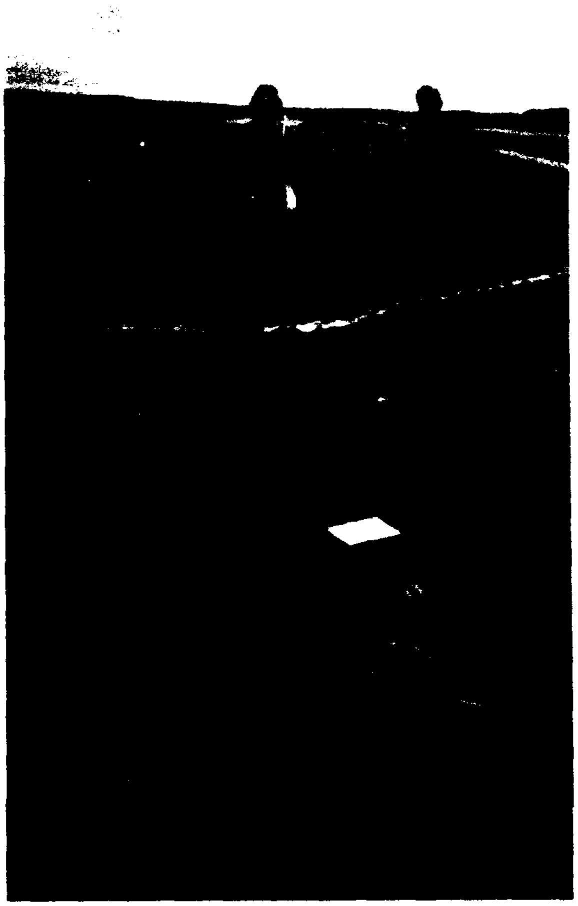


Figure 25 (cont'd).

plow wheel loading. These cracks probably occurred early or late in the snowfall season, before the subgrade was frozen or after it had thawed. Figure 26b shows possible fatigue cracking in the wheel path of a taxiway. This is one of the very few instances in which fatigue cracking was observed at the airports visited.

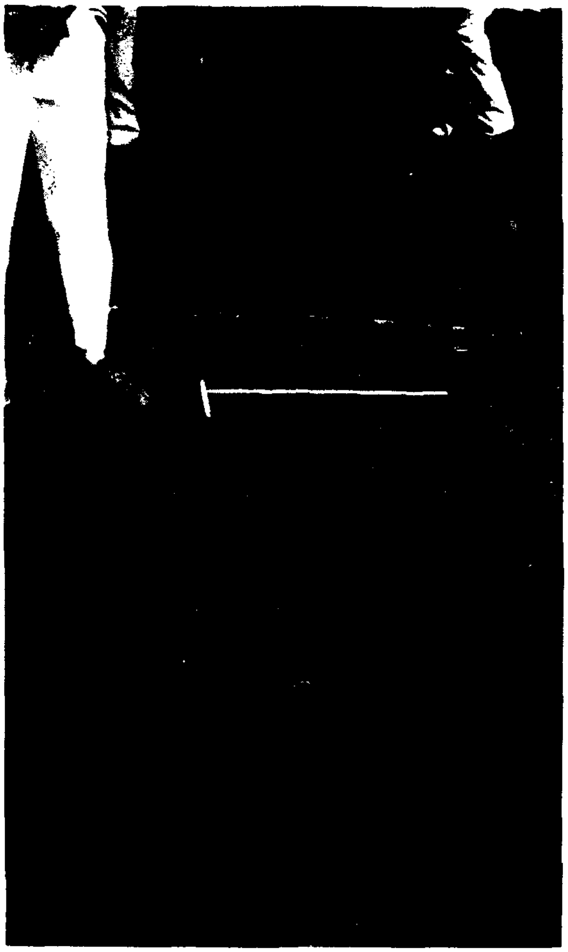
Reflection cracks are an expression of the crack pattern in an underlying pavement layer. They are caused by horizontal and/or vertical movements across a crack or joint in the pavement beneath an overlay. Reflection cracks were observed in both asphalt overlays on old PCC pavements and in asphalt overlays on old AC pavements. Reflection cracks can occur very soon after construction of an overlay. Figure 27 shows reflection cracks that occurred 6 to 12 months after an overlay was constructed.

In an attempt to minimize reflection cracking, it has been suggested that a geotextile could be placed between the overlay and the old pavement surface (Eaton and Godfrey 1981). An example encountered during the site visits is shown in Figure 28. In the installation, the cracks in the existing surface are filled and a tack coat is applied to the surface (which may or may not be milled). The geotextile is placed on the surface and the overlay is constructed. Results to date suggest that this technique may minimize reflection cracking in temperate climates, but it has not appreciably reduced reflection cracking for installations in cold regions.

Reflection cracking was noted in the questionnaire survey as a major problem area by airport

a. Cracks associated with snow plow wheel load.

Figure 26. Traffic/load-associated cracking.



b. Fatigue cracks in wheel path of taxiway.

Figure 26 (cont'd). Traffic/load-associated cracking.

managers/executives. The site visits confirmed their concern. While several construction strategies (e.g. geotextiles, thicker overlays, more "compliant" overlays) are being discu. ;ed at this time, it would appear that the only proven way to eliminate reflection cracking is to completely remove the old pavement (recycle into the base, and so forth) and reconstruct a new pavement.

Cracks were observed in AC pavements on occasion that could not be categorized with respect to the modes of distress noted in Table 1. Figure 29a shows cracks in the parking apron of an airport that were believed to be related primarily to poor drainage beneath the apron. The direction of drainage and the approximate orientation of the apron are indicated in the photograph. During the winter snow removal activities, the snow plowed from the area was stockpiled along the north end of the apron. With spring thaw, the snowmelt drained beneath the apron. Drainage from beneath the apron was visible at the south end of the apron in June when the photographs were taken, as shown in Figure 29b. While the cracks may, in part, be traffic/load-related or associated with thermal contraction, the strong possibility that they are related to a great degree to the excess water beneath the pavement cannot be ignored.

Cracks were also observed in PCC pavements during the site visits. "D" or durability cracking, when encountered, caused the greatest problem for airport managers. An example of "D" cracking is shown in Figure 30a. "D" cracking is generally attributed to the inability of the PCC to resist repeated contraction/expansion associated with, for example, temperature cycles including

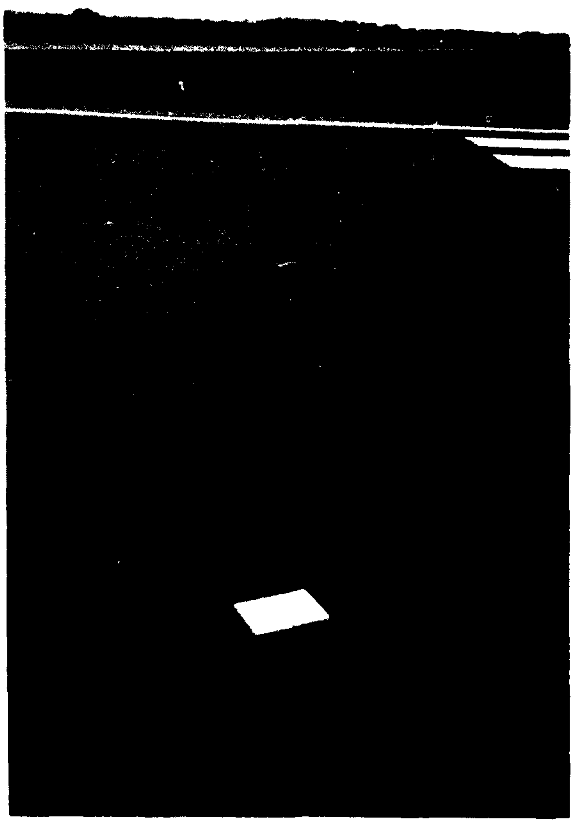


Figure 27. Reflection cracks in an asphalt overlay.

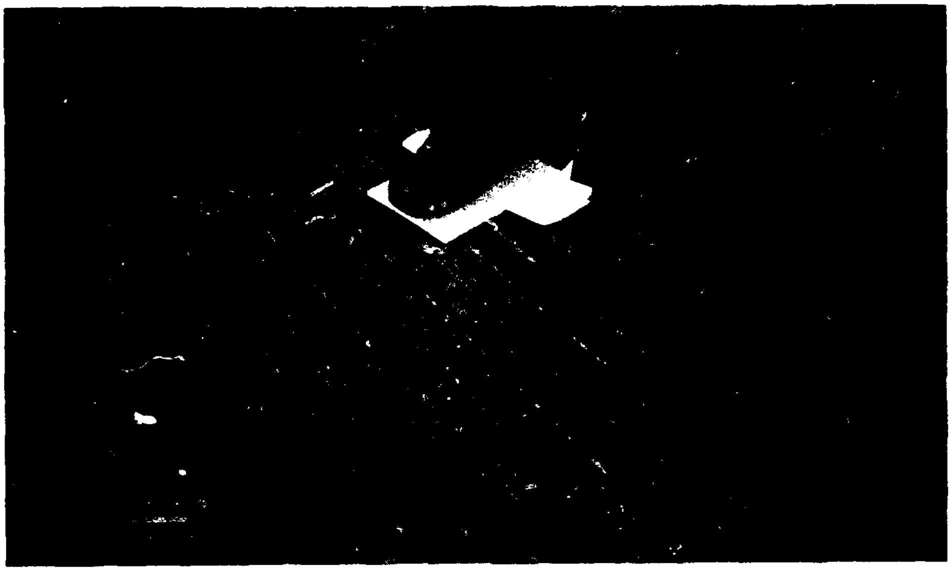


Figure 27 (cont'd).

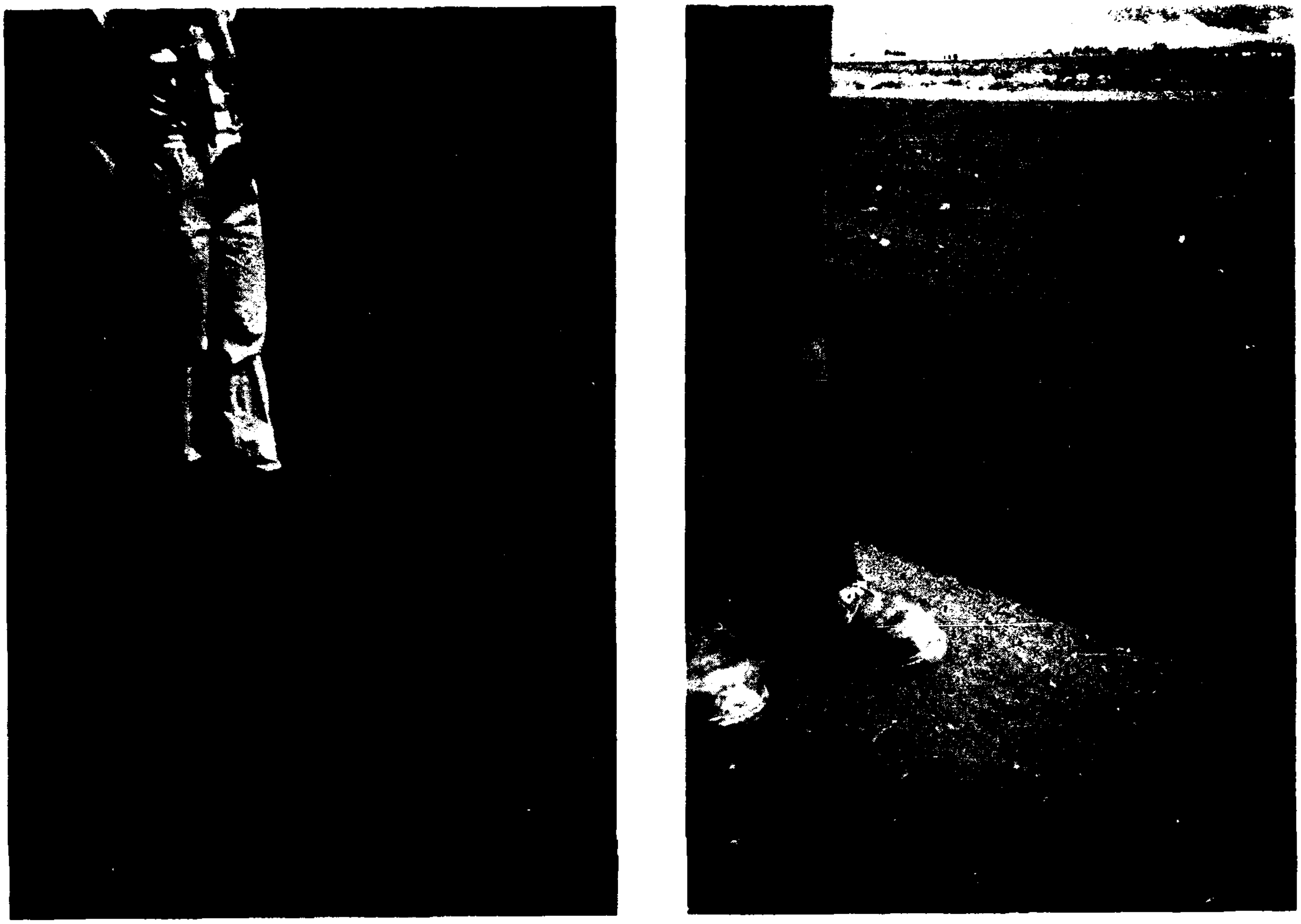


Figure 28. Geotextile placed between overlay and old pavement surface to minimize reflection cracking.

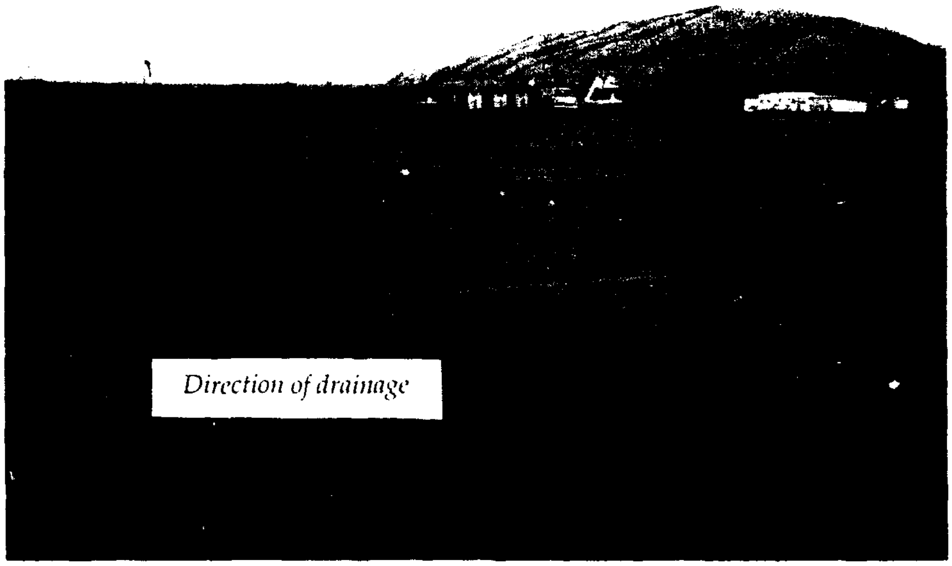
freeze-thaw cycles. "D" cracking often leads to disintegration of the concrete in the vicinity of a corner or joint as shown in Figure 30b.

Corner breaks (a vertical crack that intersects adjacent joints) were encountered. Corner breaks are often associated with loss of slab support combined with repeated loads on the slab. An example is shown in Figure 31.

Longitudinal cracks, usually caused by a combination of repeated loads and thermal contraction or shrinkage, were also observed during the site visits. An example is shown in Figure 32.

Distortion and pavement faulting

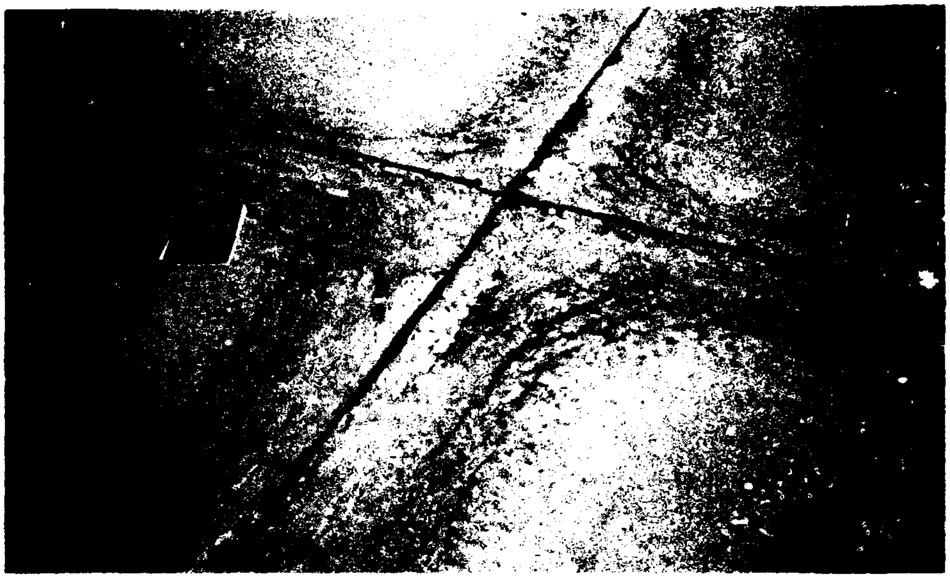
Frost heave was the primary cause of the distortion (movement) and faulting of the pavement surface observed at the sites visited in the study. While distortion is greatest toward the end of the winter, remnant evidence of the distortion was often apparent during the June, July, and August time frame in which the sites were visited. It is universally recognized that three conditions are necessary for frost heave and the formation of segregated ice to occur. First, ground temperatures must be sufficiently low and prolonged such that the soil water freezes. Second, the available water table must be close to the freezing front in the soil mass so that water can migrate to a growing ice lense. Third, the soil must be susceptible to the formation of segregated ice. The basic approach to control frost heave is to eliminate one or more of these conditions. In the field, temperatures and available water cannot be easily controlled. Therefore, identifying and rejecting or removing a frost susceptible soil is the most common approach used to control frost heave.



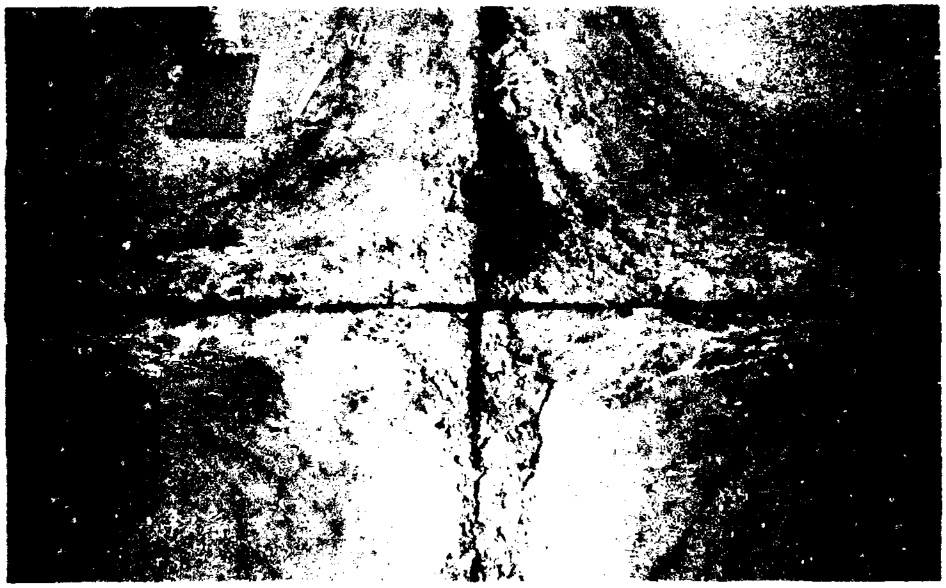
a. North end of parking apron.

b. South end of parking apron.

Figure 29. Cracks in a parking apron believed to be related to poor drainage.



a. Characteristic pattern of "D" cracking in the vicinity of slab corners.



b. Disintegration of concrete related to "D" cracking.

Figure 30. "D" cracking in a PCC pavement.

Figure 31. Corner breaks associated with loss of slab support and applied load.

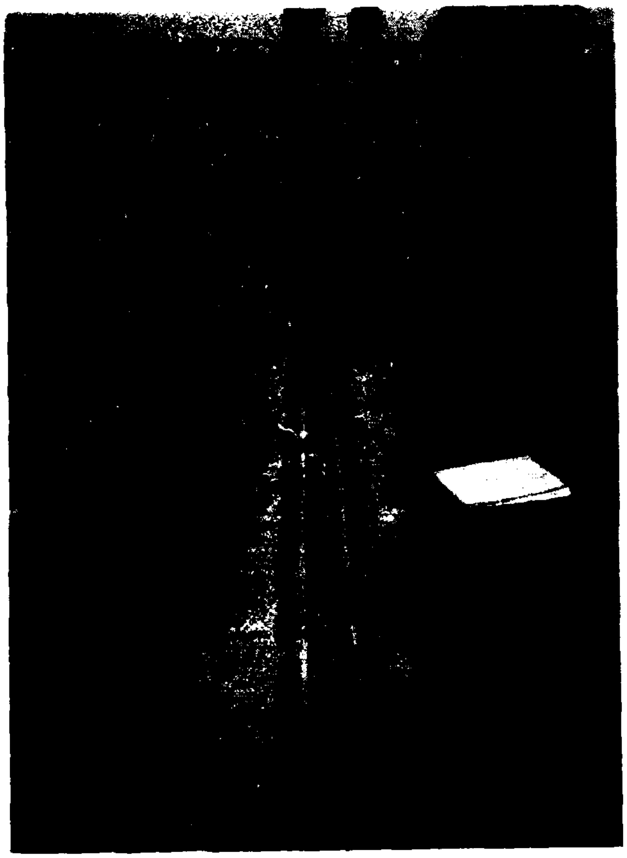


Figure 32. Longitudinal crack in PCC associated with thermal contraction and applied loads.

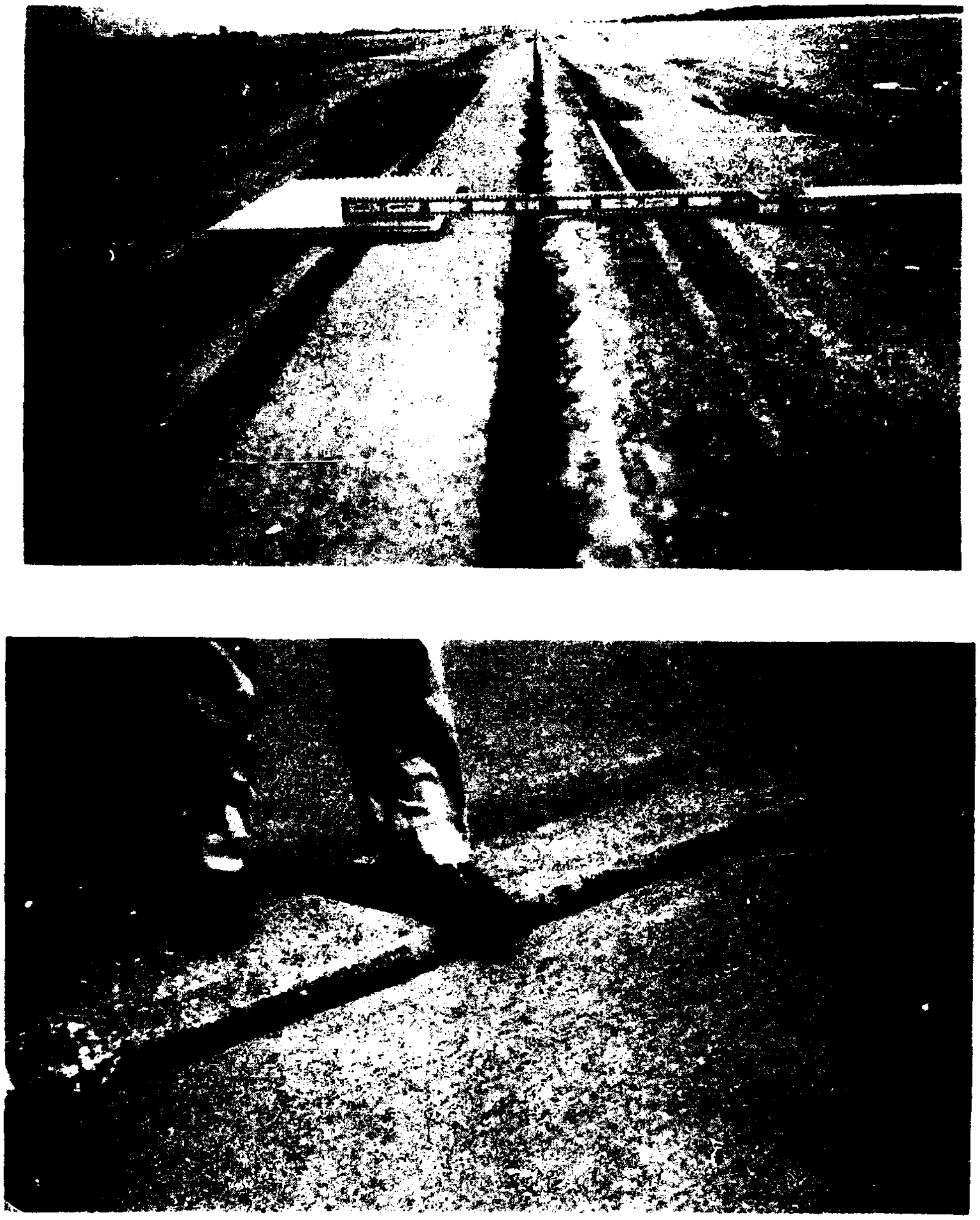


Figure 33. Distortion of PCC pavement surface caused by frost heave.

Differential movements associated with frost heave are shown in Figure 33. All of the movements are associated with PCC pavements that, owing to the rigid slabs associated with their construction, do not easily return to their original position following spring thaw.

Evidence of differential movements for AC pavements after spring thaw was generally suggested by scrape marks from a snow plow blade, as shown in Figure 34. Very often, however, differential movement was not obvious in AC pavements during the site visits. Where it was obvious, it was generally associated with loss of fines beneath the distorted section that resulted in "lipping" at a crack or the formation of a residual "birdbath." These conditions are shown in Figure 35.

Over the past 10 years, the Federal Highway Administration (FHWA), FAA, and U.S. Army Corps of Engineers have jointly funded a project to develop improved predictive methods to characterize frost effects on highway and airport

Figure 34. Distortion of AC pavement surface caused by frost heave.

a. "Lipping" at a crack.

b. Residual "birdbath."

Figure 35. Distortion associated with loss of fines beneath an AC pavement.

pavements. Under the project, a mathematical model was developed to compute frost penetration and frost heave during the winter months and thaw penetration and the soil water regime during spring thaw (Berg et al. 1980, Guymon et al. 1986). A schematic illustration of the application of their frost heave/thaw consolidation model to pavement design in seasonal frost areas is given in Figure 36. As may be noted, laboratory tests are required to create input data for the model.

A consideration of frost heave suggests the related problem of thaw weakening, and in extreme cases, soil instability due to excess water

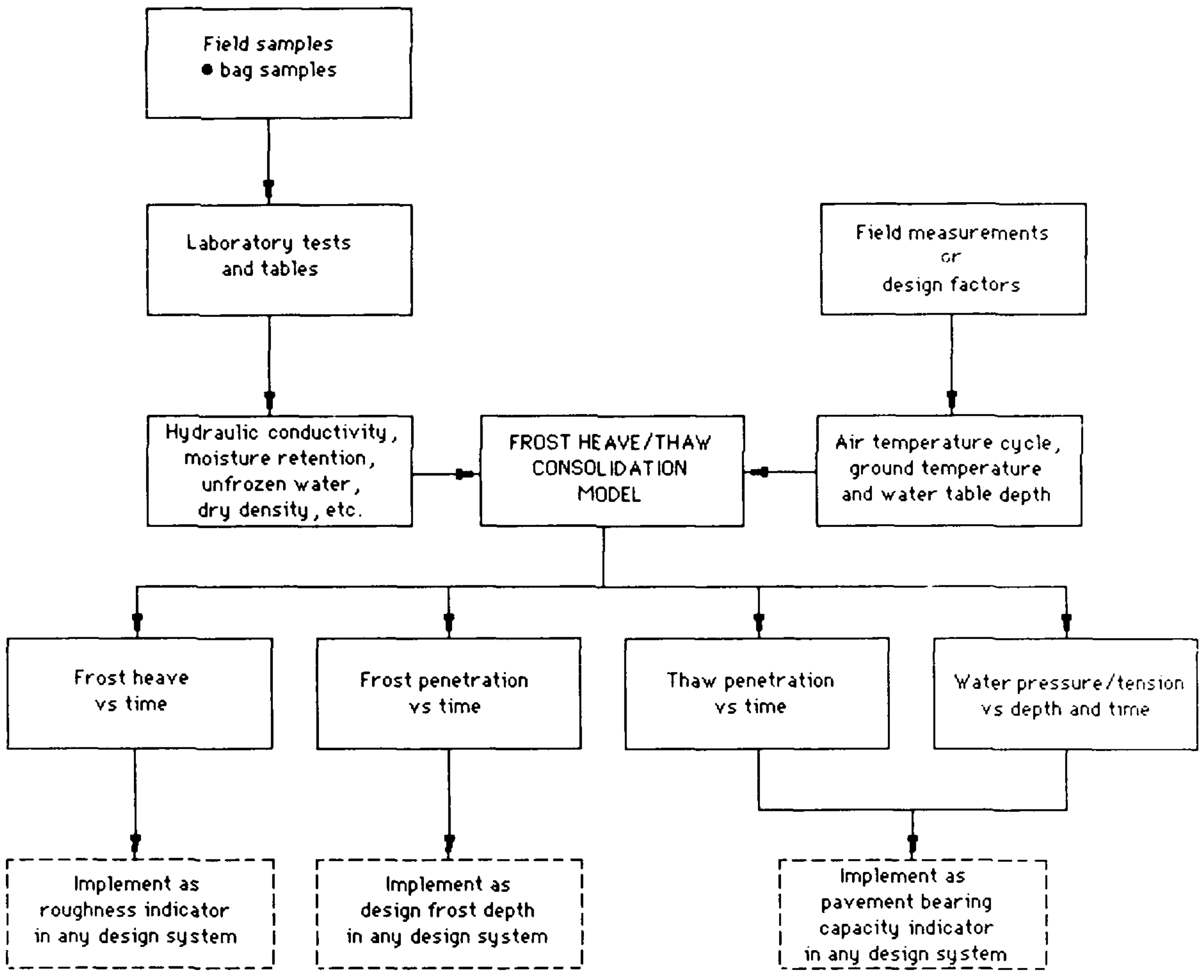


Figure 36. Schematic illustration of the applications of a frost heave/thaw consolidation model to pavement design (after Guymon et al. 1986).

when the segregated ice (associated with frost heave) thaws. Pavement deterioration under repeated loads is a process of cumulative damage. During spring thaw, the supporting capacity of a pavement surface layer provided by the base, subbase, or subgrade can be substantially reduced owing to excess pore water in the supporting layers. Consequently, during these periods, damage accumulation for a given traffic volume and load is greatest and can lead to a substantial reduction in overall pavement life.

Adequate drainage provisions can mitigate thaw weakening and damage accumulation in a pavement structure. A common meltwater regime is shown in Figure 37. As thaw progresses from the surface downwards, the water released can "pond" beneath the pavement (since the ground is frozen beneath and lateral redistribution of the water is often not possible because of slower thawing and/or less permeable soils in the vicinity of the shoulders). The situation points to the definite need for free-draining base and subbase courses and longitudinal drains to remove the thaw water in frost areas. Further, impedance of subsurface drainage elements caused by frozen soils must be considered in the design process (Berg and Johnson 1983).

The greatest differential movements observed were often associated with differences in soil frost heave response. Figure 38 shows evidence of a difference in soil response between the backfill material in a culvert trench and the adjacent soil underlying the pavement. The backfill material appears to exhibit greater frost heave than

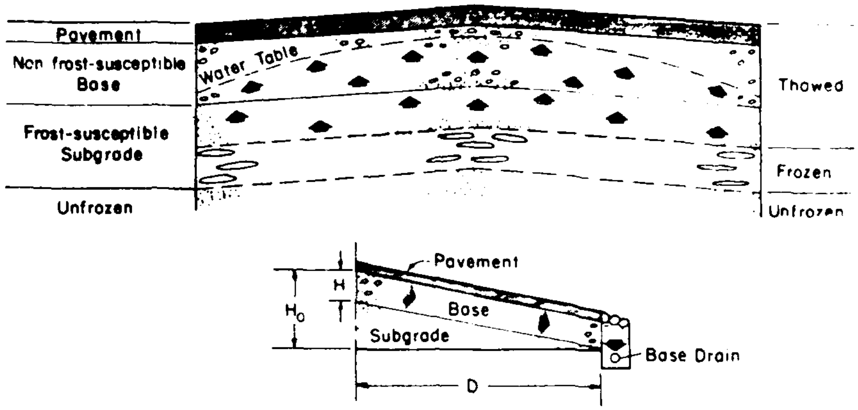


Figure 37. Thaw water regime in a pavement structure underlain by frost-susceptible subgrade (after Berg and Johnson 1983).

Figure 38. Damage caused by differential frost heave across a backfilled culvert trench.

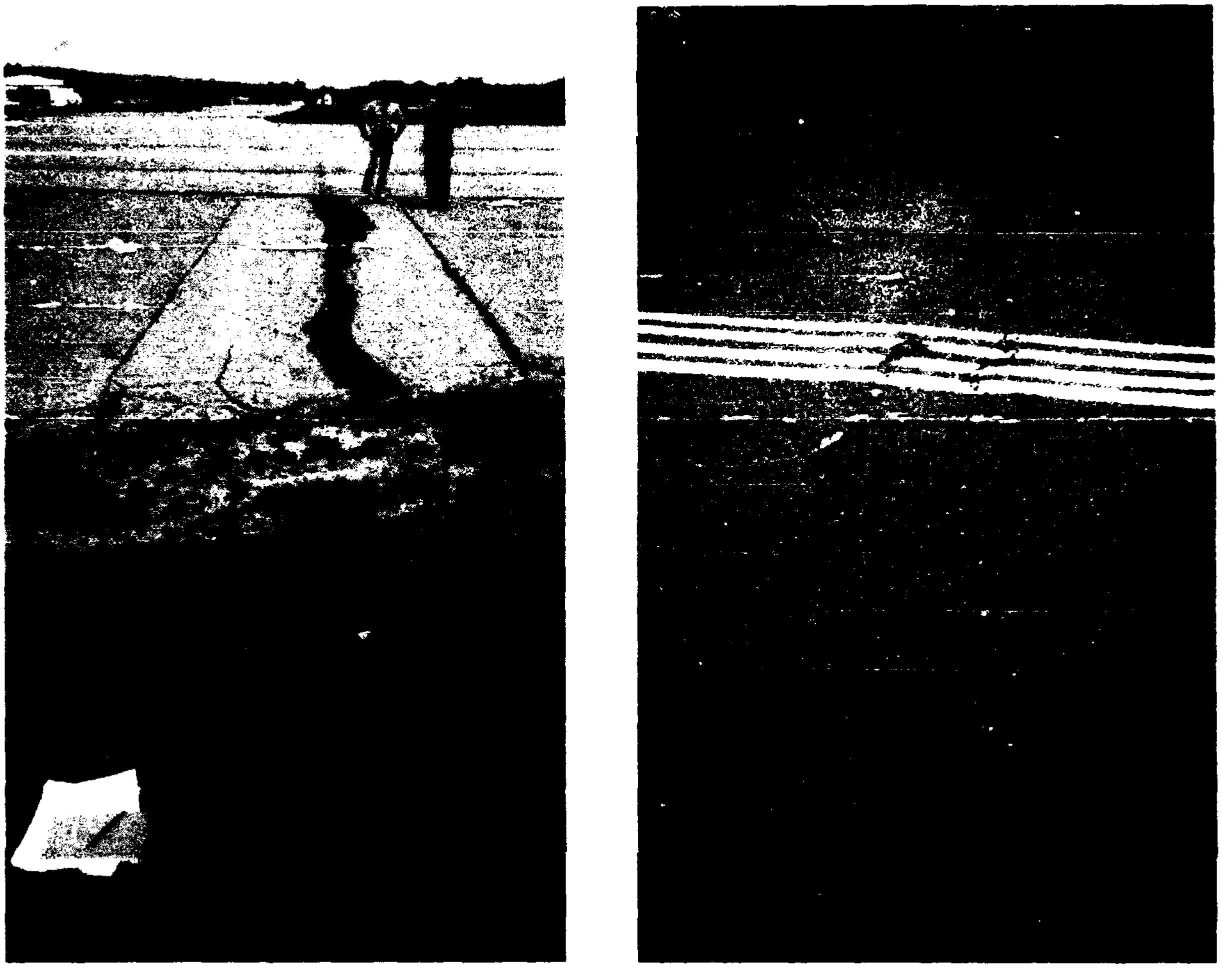


Figure 39. Consequences of differential frost heave in the vicinity of an abandoned culvert trench backfilled with material "matching" surrounding subgrade soils.

the adjacent soil. Figure 39 shows a similar situation in which a nonfunctioning culvert pipe was removed from beneath a pavement and the trench was backfilled with soil that was believed (by the airport maintenance foreman) to be identical to the adjacent soil underlying the pavement. While the differential movement is perhaps reduced, it is apparent that the soil conditions were not matched exactly.

Berg and Johnson (1983) also note that drains, culverts, or utility ducts placed under pavements on frost-susceptible subgrades often experience differential heave and should be avoided. They provide guidelines for transition zones around culverts or utilities that must be placed beneath pavements on frost-susceptible soils, as well as longitudinal and transverse transitions to accommodate interruptions in pavement uniformity. When relatively short portions of airfield pavements are reconstructed, the potential for differential frost heave beneath the new and old pavements should be evaluated and adequate transitions should be installed.

Distortion distress is also associated with 1) buried structures remaining fixed while the surrounding soil heaves and 2) buried structures "jacking" out of the ground under successive freeze–thaw cycles. Figure 40 shows patching in an apron adjacent to an intake structure for a storm drain system. The intake structure is buried well below the depth of frost penetration and remains "fixed" while the subgrade soil beneath the parking apron heaves. Substantial cracking has occurred adjacent to the structure that has

Figure 40. Patching in parking apron adjacent to fixed intake structure for a storm drain system.

subsequently been repaired. Figure 41 shows a pipe culvert that was not buried below the depth of frost penetration and has been"jacked" out of the ground.

Disintegration

Disintegration is the breaking up of a pavement into small, loose particles. In an AC pavement, disintegration is generally related to insufficient asphalt content in the mix, asphalt stripping, moisture-induced softening of the asphalt cement, poor compaction of the mix, or overheating of the mix. In a PCC pavement, disintegration may be caused by unsuitable aggregates, or improper mixing, curing, or finishing of the concrete. Disintegration may be accelerated by freeze-thaw cycles, or traffic loading, especially adjacent to cracks. Examples of disintegration observed during the site visits are shown in Figures 42 and 43.

Inadequate skid resistance

Adequate surface frictional resistance of airport pavements under all weather conditions is necessary to ensure safe operations. Loss of surface friction, or skid resistance, in both AC and PCC pavements can be related to aggregates that have been polished under traffic and buildup of rubber deposits over a period of time. Loss of skid resistance in AC pavements may also be associated with bleeding, typically caused by too much asphalt in the mix. Hydroplaning (i.e. the buildup of a thin layer of water between the pavement and tire) is obviously an extreme case of loss of skid resistance.

To improve skid resistance and eliminate hydroplaning, two techniques were employed at the general aviation airports visited. As shown in Figure 27, grooves are cut transverse to the direction of travel allowing water to drain from the surface and roughening the surface. Also, a porous friction course (PFC) may be used, as shown in Figure 44a. As defined previously, a PFC is an open-graded mix with a high asphalt content. Because of the large volume of air voids present between the coarse particles, water can readily drain through the mix, as shown in Figure 44b.

Concern was expressed during the site visits about the standard to be applied to measure skid resistance of airport pavements. Typically, airport managers/executives drive their vehicles at moderate speeds during adverse weather and apply the brakes to assess skid resistance. They make their own subjective assessment of whether or not the pavement has adequate skid resistance. Clearly, this approach is not satisfactory.

Figure 41. Pipe culvert at shallow depth of burial "jacked" out of ground over a period of several years by frost heave.

Figure 42. Disintegration in the vicinity of the corner of a PCC pavement.

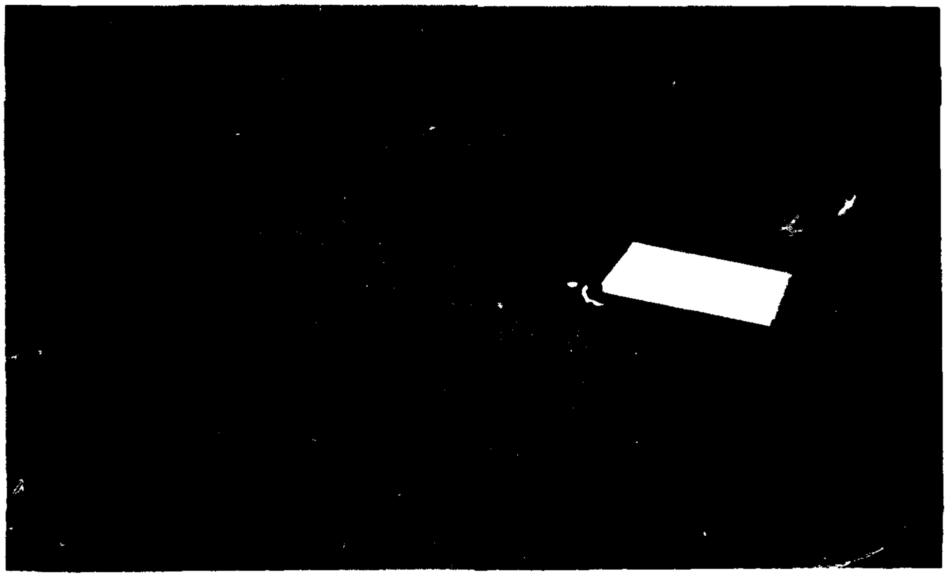
Improper maintenance

Maintenance of airport pavements is obviously related to all of the distress modes previously discussed. It is identified as a separate pavement performance problem in this discussion, however, because it was common to all of the airports visited and, in many instances, is the most serious concern of the airport managers/executives. Guidelines and procedures for the maintenance of airport pavements have been addressed in an FAA Advisory Circular (U.S. DOT 1982).

Fromm and Phang (1972) note that transverse cracks caused by the overall contraction of the pavement structure and subgrade are not as serious as cracks occurring wholly in the AC surface layer. Cracks restricted to the AC surface layer allow ingress of water, which in turn increases 1) the rate of stripping and moisture-induced distress in the AC, and 2) allows pumping of a fine granular base course. Water entering the crack during the winter may result in the formation of an ice lens below the crack, which produces upward lipping at the crack edge. Also, deicing solutions enter the crack and cause localized thawing of the base which, in turn, may result in a depression around the crack. Cedergren and Godfrey (1974) note that 70% of surface runoff can enter a crack 1 mm (0.04 in.) wide.

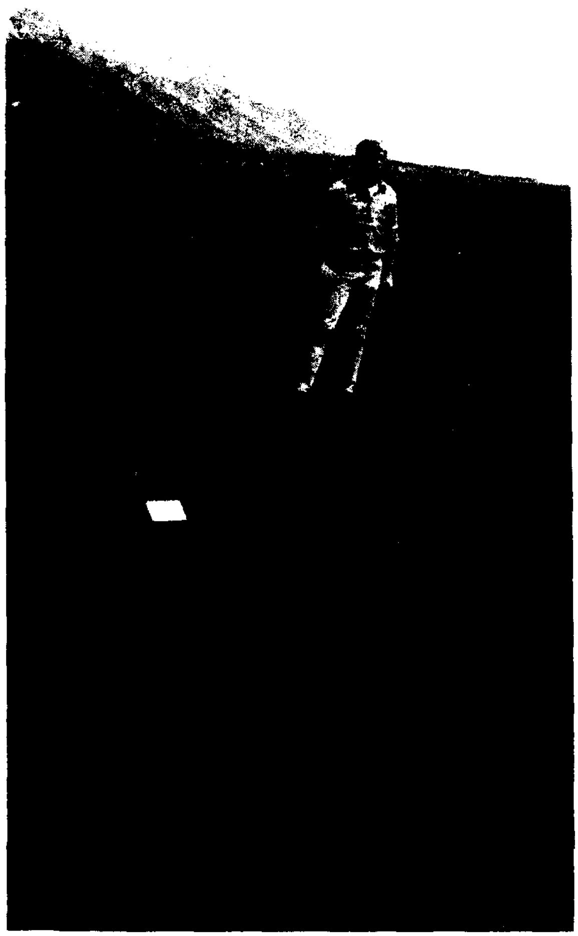
The commonly accepted procedure to fill a crack is shown in Figure 45. First, the crack is routed to a width of approximately 10 mm (0.4 in.) and depth of 20 mm (0.75 in.), and blown clean with compressed air. Second, the crack is filled with a sealant material. If the crack is very

Figure 43. Disintegration in an AC parking apron.



a. Typical appearance of a porous friction course.

Figure 44. Porous friction course.



b. Water drainage through a porous friction course.

Figure 44 (cont'd).

wide initially, a blocking material is often placed in the crack to reduce the amount of sealant. Finally, sealant is poured into the crack. The cross section of a typical routed and sealed crack is shown in Figure 46a.

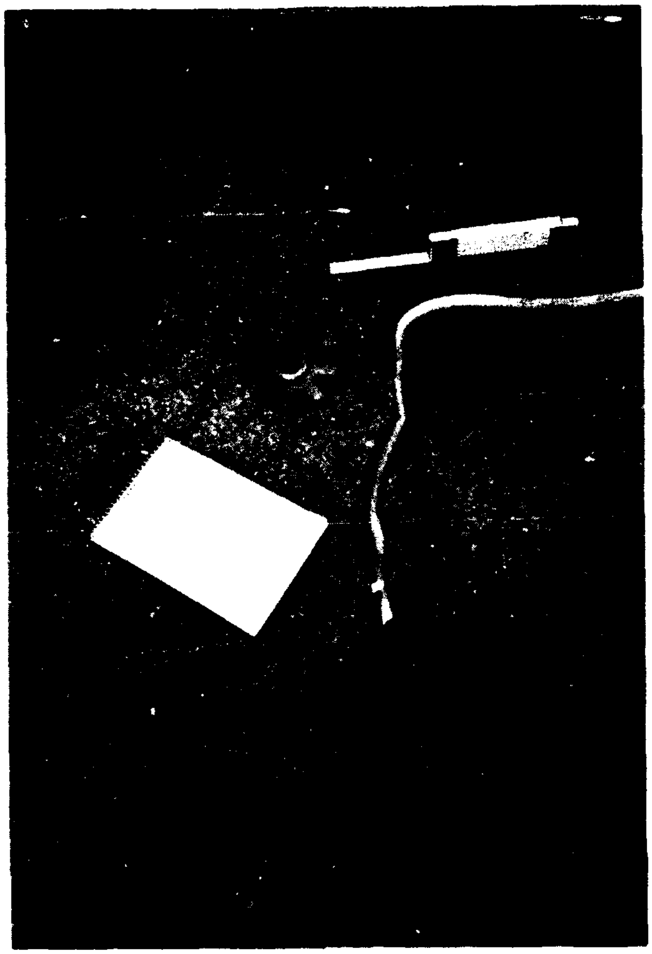
Evers and Lynch (1984) report results from a research program on crack sealing conducted by the Ontario Ministry of Transportation and Communications. They emphasize the need to extend the sealant well beyond the limits of the crack (overband sealing) and provide a thickness of 2 to 3 mm (0.08 to 0.12 in.) at the edge of the rout. They further identify several possibilities for failure of a seal as shown in Figures 46b and c. They note that the sealant must be struck off so as to leave a bead of material over the routed groove with the edges of the material feathered out. If the sealant stands too high, it is subject to snowplow damage, as shown in Figure 47.

Evers and Lynch (1984) also identify a new crack sealant geometry that maximizes the benefits of the overband seal, eliminates snowplow damage, and controls the width of the sealant spread. The geometry is shown in Figure 48. They note that countersinking the overband eliminates the need for a strike-off operation.

If cracks are extremely wide, or if multiple cracks exist, as shown in Figure 49, then crack filling will be ineffective. In this case, a section of the surface is cut out and replaced, as shown in Figure 50. Often, however, the patch itself becomes cracked or new cracks develop at the edge of the crack, creating two cracks where ini-

a. Crack routing tool and compressed air nozzle.

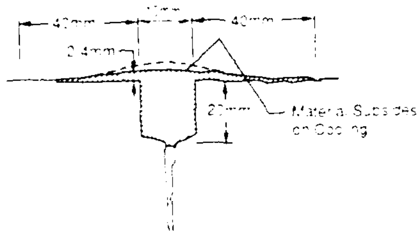
Figure 45. Commonly accepted crack filling procedure.



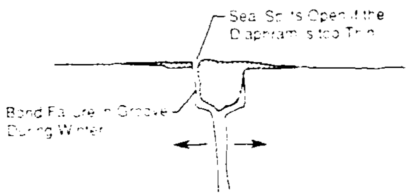
b. Routed crack with foam rubber blocking material inserted.

c. Sealed crack with flexible sealant.

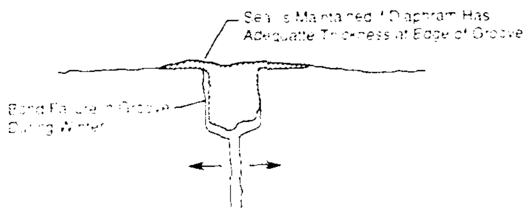
Figure 45 (cont'd). Commonly accepted crack filling procedure.



a. Typical sealed crack cross section.



b. Diaphragm failure.



c. Bond failure at groove.

Figure 46. Cross section of sealed crack and typical failure modes (after Evers and Lynch 1984).

Figure 47. Sealant pulled from crack during snowplow operations.

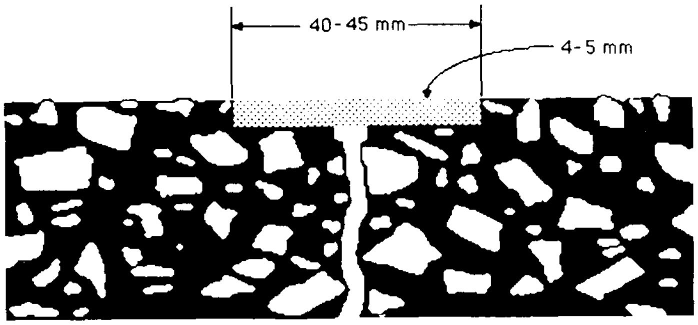
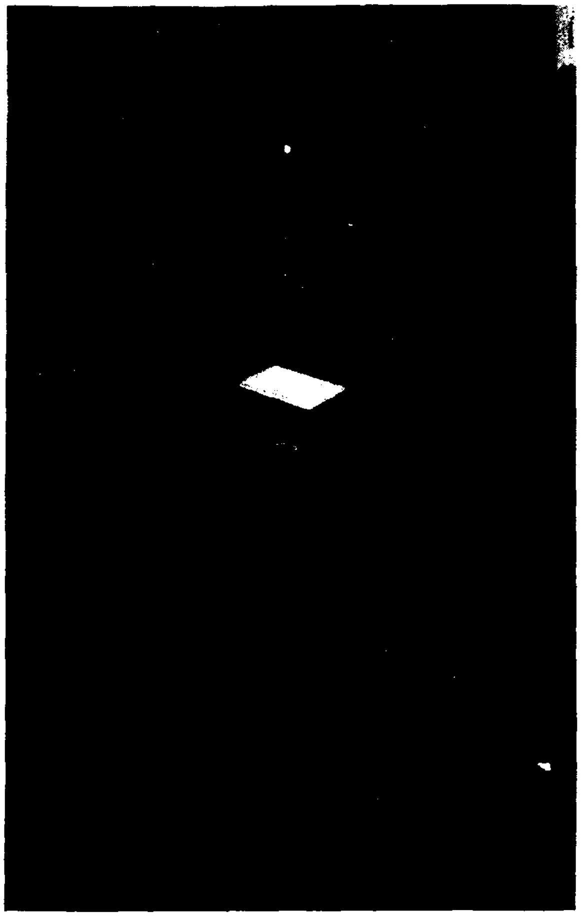
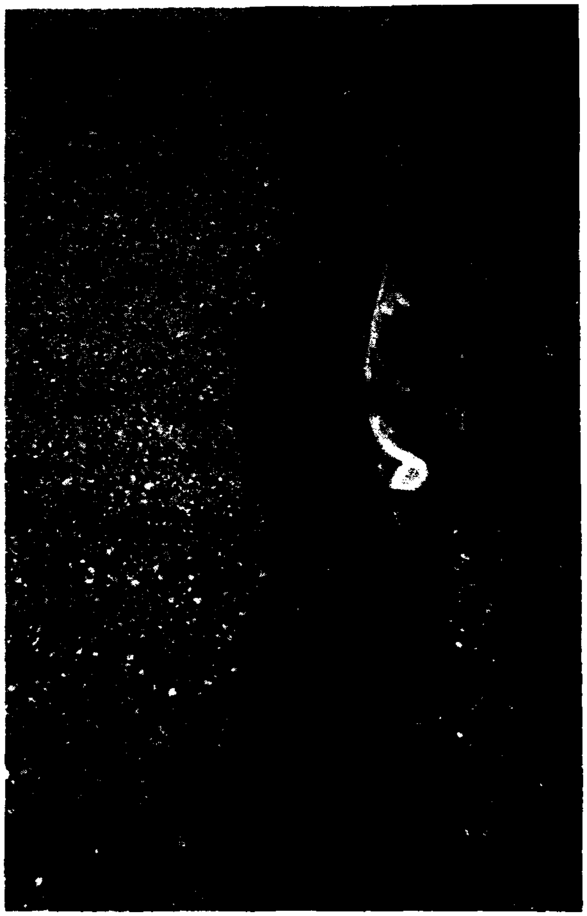


Figure 48. Cross sections of countersunk overband seal (after Evers and Lynch 1984).





a. Extremely wide transverse crack.

b. Multiple transverse cracks (owing to primary and secondary transverse cracking).

Figure 49. Cracks that cannot be effectively sealed.

Figure 50. Replaced pavement section to repair multiple transverse crack.

tially there may have been only one. Examples of cracks through and adjacent to patches are shown in Figure 51.

Evers and Lynch (1984) indicate that cold paved sealants are not satisfactory for sealing AC pavements. Hot poured sealants, meeting requirements conforming to ASTM D-3405, performed satisfactorily at locations with temperatures down to -10°C (14°F), but sealants meeting requirements conforming to ASTM D-1190 performed marginally. They note that sealants with a low stiffness modulus are often removed by snow plows and sealants with high stiffness moduli are sheared off. Further, well-bonded sealants occasionally induce secondary cracking close to the original sealed cracked. Figures 52a and b illustrate additional sealing problems in the summer. As the sealant softens during the warm summer months, it may reduce in viscosity to the extent that it disappears in the crack.

Stripping

Stripping of an AC pavement is the loss of adhesion between the asphalt cement and aggregate. Stripping is due to the action of water or water vapor in the AC pavement. Specifically, water gets between the asphalt cement film and the aggregate surface. Since the aggregate surface generally has a greater attraction for water than asphalt, the water is drawn between the asphalt cement and aggregate surface and strips the asphalt away from the aggregate. The rate at which stripping takes place depends on the temperature, type of aggregate, and viscosity and composition of the asphalt (Tyler 1938).

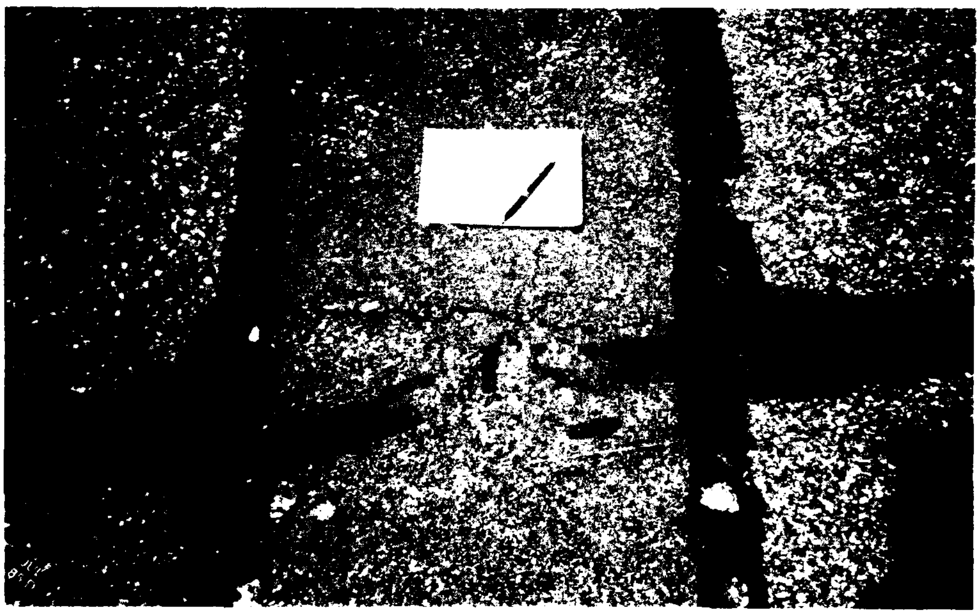
Two characteristic types of pavement failures are associated with stripping. If water enters the asphalt cement pavement through the upper surface, raveling of the aggregate occurs. If stripping occurs from the bottom of the pavement upwards, random cracking and potholing result. Raveling of the aggregate at the surface may be detected and often remedied with routine maintenance. Stripping, which results in random cracking and potholing, is generally not detected until it is too late to prevent.

Concern for stripping suggests that the AC should be densely compacted to achieve maximum impermeability. If the pavement has a high voids content, water will enter at the surface and create the potential for stripping. In addition, as noted previously, water can enter the pavement through cracks.

Winter snow removal practices can also create a potential for stripping. Snow plowed to the sides of runways prevents the frozen shoulders from thawing during warmer periods. The frozen shoulders act as a barrier to drainage of free water provided by deicing salts/solutions or snow/ice thaw associated with the heat-absorbing black asphalt pavement.

Pavement distress associated with stripping was not specifically noted during the site visits. However, potholes and aggregate raveling are maintenance problems that require immediate attention at airports. Consequently, many of the repaired potholes observed during the site visits could have been associated with stripping. Certainly, many of the cracks observed which appeared to be random in their occurrence could be related to stripping.

a. Crack at construction joint between replaced pavement section and old pavement structure.



b. Longitudinal crack propagation across replaced pavement structure.

Figure 51. Cracks in the vicinity of replaced pavement section.

a. Stickiness and bubbling associated with softening.

b. Sealant loss into crack.

Figure 52. Sealant problems arising during summer.

STATEMENT OF RESEARCH NEEDS

Basis for statement of research needs

The purposes of the study reported here were to 1) identify problems unique to airport pavement performance and maintenance in cold regions, and 2) define research programs to eliminate or minimize the problems. The problems unique to airport pavement performance and maintenance in cold regions were presented in the previous section. Research program needs are discussed in the following sections. The discussion of research needs is not exhaustive and is based only on the survey work performed for this study. Identification of a research program need does not ensure that funding for a program will be available through state or federal sources.

Performance of overlays

Perhaps the most extensive problem identified by the survey effort was related to the unexpectedly short life of pavements rehabilitated using asphalt concrete. In many instances, asphalt concrete overlays were placed over cracked AC or PCC pavements to eliminate water infiltration through the pavement into the base course and subgrade and/or improve ride quality. Too often, nearly all of the remnant cracks reflected through the overlay in a year or less, causing airport managers and the general public to question the ability of engineers to solve pavement-related problems. Many millions of dollars are expended each year to overlay cracked and deteriorated airfields. However, many of the repairs are ineffective after a short period of time, and costs of crack sealing increase to levels that equal or exceed those prior to the overlay. Rather than gaining 10 to 15 years of low maintenance costs expected from the overlay, the airport experiences reduced costs for only one or two years.

At least three avenues of research should be explored to alleviate problems related to reflection cracking through the relatively thin overlays used in general aviation airports, as follows:

1. Determination of asphalt cements and aggregate blends to minimize/prevent reflection cracking.

2. Investigation of asphalt concrete properties and specifications to determine whether mix designs could be altered to reduce reflection cracking.

3. Examination of additives to determine their usefulness to prevent reflection cracking in asphalt concrete mixes.

4. Investigation of the use of geotextiles or other reinforcing materials at the interface between the overlay and old pavement to minimize/prevent reflection cracking.

Recycling/reconstructing airport pavements

Recycling of pavements will increase in future years. Several questions must be addressed in a research program to ensure improved performance, as follows:

1. Should recycling be for the full thickness of the paved surface?

2. Can additives, new asphalt concrete or aggregate be added to provide suitable wearing courses or should recycled asphalt concrete be used only as a base course?

3. How can cracking in a recycled pavement structure be minimized?

4. Can cold-mix recycling be used in airport pavement reconstruction?

5. Can PCC pavements be recycled as aggregate for new PCC or only as a subbase ?

Drainage of airport pavement structures

Another widespread problem identified is the lack of adequate drainage of airport pavements. This reduces pavement life by contributing to increased differential frost heave and more extensive thaw weakening. Frost heave and thaw weakening compound the problem by causing more rapid and widespread pavement cracking, which allows greater infiltration of water and, in turn, causes more severe frost heave and thaw weakening. Since water is one of the three requisites for frost action, removal of water will eliminate the problem of frost heave and thaw weakening. Questions that must be addressed in future research programs include the following:

1. Can lateral drains at the edge of the pavement provide satisfactory drainage or are runways too wide for this technique to be successful?

2. What drainage methods or techniques are practical for wide runways?

3. Perhaps lateral drains at pavement edges will be satisfactory in some environments. What are the environments?

4. What are the optimum drainage designs for newly constructed or entirely reconstructed pavements, including material specifications?

Eliminating/accommodating differential frost heave

As airport pavement structures are constructed and reconstructed, the possibility of abrupt changes in surface elevation due to differential frost heave becomes more likely. Differences of 2.5 to 5 cm (1 to 2 in.) were common and several airport managers indicated differential movement on the order of 7.5 to 15 cm (3 to 6 in.). Generally, these movements occur at intersections between runways, taxiways, or parking aprons of different pavement structure construction and, therefore, are not a major hazard to fast-moving aircraft. However, at runway intersections or longitudinal reconstruction zones, differential movements can represent an extreme hazard to aircraft during takeoff or landing. Further, intersections at taxiways and runways may be closed due to excessive differential frost heave and this can cause delays to aircraft exiting terminal facilities, problems with snow removal, and extreme hazards to pilots not familiar with the airport. Tapered transitions can eliminate these problems, but the designer must know or estimate the amount of frost heave of the two features. Recognizing this situation, the following research programs are appropriate:

1. Investigations to improve our ability to predict differential frost heave. This program should involve a combined theoretical, laboratory, and field effort.

2. Determination of required length and geometry of transition zones as a function of the velocity and type of aircraft, type of facility, and differential frost heave at each end of the transition.

Evaluation of adequacy of design procedures

Thickness design procedures and material specifications should be evaluated for airports in cold regions. Observations made at airports in several locations indicated very high water tables and highly frost-susceptible soils close to the bottom of both AC and PCC pavements. During the site visits, only a few pavements were observed that had failed due to structural overloads. This is due, in part, to the fact that most facilities are upgraded to carry heavier aircraft or rehabilitation is required due to non-load-associated pavement failures before the design life of the existing pavement is reached. During the late 1970s and early 1980s, the FAA, FHWA, and Corps of Engineers jointly developed more refined laboratory tests and computer programs which can be used to design and evaluate airfield pavements in seasonal frost areas. These techniques should be applied to actual airfield pavements as well as full- and reduced-scale airfield pavement test sections for evaluation and refinement. The airfield pavement test sections could be carefully constructed and subjected to controlled environmental conditions and aircraft-type traffic loading until failure.

Maintenance products and performance

Unfortunately for airport managers, airport engineers, and taxpayers, inadequate information exchange exists on the many products used for pavement maintenance. Also, maintenance products recommended by manufacturers' representatives often do not produce the desired results. Further, some products function properly only when used in conjunction with other products or when applied using a specific procedure. Information exchange on state or regional levels must be encouraged and facilitated. Perhaps training courses for airport maintenance personnel are desirable. Finally, it appears that no comprehensive study has been conducted in the U.S. on how to prepare and fill cracks in flexible and rigid pavements in cold regions. Generally, a standard procedure of routing and sealing which lasts a couple of years (at most) is employed. Research should be conducted to:

1. Determine which maintenance products and procedures (e.g. crack sealants, seal coats, etc.) are most suitable for specific applications and environments.

2. Identify the best procedure to fill a crack once it occurs as a function of severity of cracking. The effort should include a consideration of the geometry of the crack seal and the environment under which the sealant is applied.

3. Identify the cost/performance benefits associated with a comprehensive preventive maintenance program.

Other maintenance problems were revealed during the site visits that suggest research programs to address the following questions:

1. What procedures should be used to clean rubber from porous friction courses?

2. Should sand seals be used to improve braking resistance in areas of low temperatures and snow?

Control of transverse cracking

Transverse cracking is a problem inherent to asphalt pavements in cold regions. While the phenomenological mechanism associated with the development of transverse cracks has been studied and research to define asphalt properties to ameliorate transverse cracking has been conducted, apparently no research has been performed to identify field techniques to control transverse cracking. For example, it may be possible to saw transverse joints (possibly at a diagonal) in a pavement structure and minimize the effects of uncontrolled transverse cracking. Research into field control techniques for new and in-service pavement structures is highly desirable.

Additives for asphalt concrete

Substantial benefit may be derived when additives are introduced into an asphalt concrete mix. For example, crumb rubber and asbestos fiber additives have been used with success in airport pavements in cold regions (asbestos is no longer used because of public health restrictions). Liquid rubber has also been added to the asphalt cement used in hot mix. Research is required to identify the types and quantities of additives and the associated improvements in asphalt concrete mix performance that may be realized.

Performance documentation

Many of the problems described above must be answered by long-term studies on in-service and test section pavements. A problem which has long plagued designers is one of little long-term documentation of pavement performance. A large volume of qualitative information exists on in-service performance, but very few quantitative data may be found. A comprehensive program of pavement performance documentation should be initiated.

Wildlife conservation vs aircraft safety

Wildlife can create major safety problems at airports. This is not a problem unique to airports in cold regions, but it was noted as an item of concern by several of the airport managers during the site visits. For many smaller airports it is not possible to fence the airport area and, consequently, wildlife can easily cross runways and taxiways. Further, fencing is not always effective. Obviously, there is no solution to keep birds out of the airspace surrounding the airport. Research is needed to identify innovative techniques to minimize or eliminate interactions between wildlife and aircraft.

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APPENDIX A: QUESTIONNAIRE AND LISTING OF AIRPORTS CONTACTED

February 14, 1985

Dear Airport Executive:

Under an Interagency agreement with the Federal Aviation Administration and with the cooperation of the American Association of Airport Executives, the U.S. Army Cold Regions Research and Engineering Laboratory (USA CRREL) is conducting a study to evaluate the performance of current pavement designs at airports in seasonal frost areas. If you are unfamiliar with CRREL, a brief description of its activities are enclosed (Enclosure 1).

There has been recent concern regarding airport pavement design and the effect of seasonal frost action on that pavement. In order to determine the extent of this concern or problem, we would greatly appreciate receiving your response to the enclosed survey (Enclosure 2). It will provide information for use in developing a research and evaluation study directed toward improvement of pavement design in seasonal frost areas. Depending on your response and with your approval, we may contact you to obtain additional information. Representatives from CRREL and the FAA plan to visit a few airports this coming spring to discuss specific problems.

If you wish to answer any of the questions in greater detail, please do so on the back of the survey or on a separate sheet of paper. Please include the question number (or numbers) if you prepare longer responses. We would also suggest that you consult with your engineer or engineering firm when completing this survey.

If you have any questions about the survey, please contact me, the CRREL Project Engineer, at telephone number 603/646-4100. If you prefer, you can contact Fred Gammon (telephone 608/266-2480) or Spencer Dickerson (telephone 202/331-8994) and they will relay a message to me.

Our success in developing improved pavement designs for airports in seasonal frost areas is dependent upon your cooperation and support. All airports participating in the survey will receive a summary of the findings.

Thanks for your assistance.

Sincerely,

Fred Gammon, A.A.E.
Chairman, Commuter/General
Aviation Airports Committee
American Association of
Airport Executives

Richard L. Berg
Research Civil Engineer
Geotechnical Research Branch

FDG/RLB/3392

Enclosures

Figure A1. Cover letter mailed with survey questionnaire.

1985 AIRPORT SURVEY

DESIGN OF PAVEMENTS IN COLD REGIONS

Airport Name: Example

Airport Address: ____________________

Person who may be contacated for further information: ____________________

Telephone number of contact person: ____________________

(NOTE: Neither the airport name or the name of the contact person will be used in reports unless approved by the contacat person.)

A. What three aircraft (for example, B727, Metroliner, Twin Otter) use your facility most frequently and how many departures are made by each per week?

Aircraft	Approximate number of departures per week (Circle one on each line)				
Convair 580	0-25	25-50	50-100	100-200	more than 200
YS-11	0-25	25-50	50-100	100-200	more than 200
Shorts 360	0-25	25-50	50-100	100-200	more than 200

B. Do you anticipate heavier aircraft using your facility in the next five years. Yes X No ____

If "yes," what additional aircraft are anticipated: ____________

C. What types of pavements are used on principal runways, taxiways and parking aprons at the airport? (Circle one).

Asphalt concrete Portland cement Some of each

D. Are you planning major reconstruction or new construction on runways, taxiways or parking aprons in the next five years? Yes ____ No X

E. Using your own judgement, rate the present overall condition of airfield pavements currently in use at your facility.

1.	Runways	Excellent	Good	Fair	Poor
2.	Taxiways	Excellent	Good	Fair	Poor
3.	Parking areas	Excellent	Good	Fair	Poor

Figure A2. Survey questionnaire with example response.

F. During the spring or after heavy rains water may seep upward through cracks and joints in a pavement. Do pavements at your airport experience this problem?

1. During spring thaw? Yes X No ____

2. After heavy rains? Yes ____ No X

G. Cracks and joints in pavements sometimes generate debris (pieces of concrete, stone or asphalt) due to large vertical movements as aircraft pass over them. Do pavements at your airport experience this problem?

1. During spring thaw? Yes X No ____

2. After wet periods? Yes X No ____

H. Some airfield pavements become rougher (bumpy) in later winter due to the effects of freezing and thawing. Do pavements at your airport experience this problem? Yes X No ____

I. Have you overlaid your pavements and observed that most of the underlying cracks reflected thru the overlay after *one or two years?*

Yes X-6 mos! No ____

J. Other than removing snow and ice from your pavement, what is your most troublesome winter maintenance problem affecting aircraft safety?

Sanding the runway

Please fold so that address on the back is exposed, staple or tape the edge, attach a stamp and mail.

Thanks for your help.

Richard L. Berg
Research Civil Engineer
Geotechnical Research Branch

Figure A2 (cont'd).

Airport: ______________________ Code: ______________

Contact: ______________________ Telephone: ______________

GENERAL PAVEMENT QUESTIONS

Length of airport existence: ______________________

Type of pavements: ______________________

Thickness of slabs: ______________________

Have they been overlaid: ______________________

How thick was the overlay: ______________________

How long before most cracks reflected thru the overlay: ______________

Is the pavement base stabilized: ______________________

What stabilizers were used: ______________________

Have they performed satisfactorily: ______________________

1. PCC PAVEMENTS

   A. Are your pavements reinforced: ______________________

   B. Are corners of the slabs breaking: ______________________

   C. Especially in areas receiving aircraft wheel loadings: ______________

   D. Remarks: ______________________

2. ASPHALT CONCRETE PAVEMENTS

   A. Is secondary cracking occurring and causing FOD problems:

      ____

   B. Have cracks occurred on longitudinal (cold) joints:

      ____

   C. What is the approximate spacing of transverse cracks:

      ____

   D. Remarks: ______________________

3. About how long does water normally pump up thru cracks and joints in your pavements. ______________________

4. Do some areas on the runways, taxiways and/or parking aprons tend to crack more extensively and pass more water than other areas:

   ____

Figure A3. Telephone follow-up of airport surveys.

Is there a common characteristic of these poor performing areas, e.g., low areas, high areas, wet areas adjacent to area: ____________________

5. How rough do your pavements become: ____________________
Have measurements of frost heave been made in the winter: ____________________

Do pavements become so rough they are not used for a period of time: ____________________

If so, how long a period: ____________________

Remarks: ____________________

6. Do you have lateral drains along the runways, taxiways, or parking areas: ____________________

If so, were they installed when the airport was constructed: ____________________

If not, how much later: ____________________

Do the drains carry water: ____________________
Remarks: ____________________

7. Several airport managers have problems with lighting in the winter. Do you have these problems: ____________________
Remarks: ____________________

8. Do you know how deep frost penetration is beneath the pavements at your airport: ____________________

9. Do you have constructrion drawings and records or does an AE firm maintain them: ____________________

10. What are the major construction projects involving runways, taxiways or parking areas you have planned for the next few years: ____________________

Do you expect this construction will eliminate the problems you now experience: ____________________

Remarks: ____________________

Summary of telephone interview: ____________________

Figure A3 (cont'd).

Table A1. Airport addresses and contacts.

DATE	AIRPORT NAME	STREET	CITY	ST ZIP	FAA REG	AAAE REG	CONTACT	TELEPHONE
03/04/85	MERRILL FIELD	PO BOX 6-6650	ANCHORAGE	AK 99502-0650	AAL	NW	FOUTS JOE	907-276-4044
03/11/85	FAIRBANKS INT'L AIRPORT	PO BOX 60369	FAIRBANKS	AK 99706	AAL	NW	PITCHER BRUCE D.	907-452-2151
03/08/85	JUNEAU INT'L AIRPORT	155 S. SEWARD ST	JUNEAU	AK 99801	AAL	NW	MILLER FRANK	907-789-7821
03/05/85	MASON CITY MUNICIPAL AIRPORT	PO BOX 1484	MASON CITY	IA 50401	ACE	NC	BROWN GEORGE H.	515-423-3541
03/05/85	DES MOINES INT'L. AIRPORT	6214 FLEUR DRIVE	DES MOINES	IA 50321-2854	ACE	NC	FLANNERY BILL	515-283-4255
02/28/85	FORT DODGE MUNICIPAL ARPT	RR #2	FORT DODGE	IA 50501	ACE	NC	RYAN MICHAEL D.	515-573-3881
02/28/85	WATERLOO MUNICIPAL ARPT.	RR #2	WATERLOO	IA 50703	ACE	NC	CARTER BRUCE	319-291-4483
03/04/85	SIOUX CITY MUNICIPAL ARPT	2403 OGDEN AVE	SIOUX CITY	IA 51110	ACE	NC	ION R. E.	712-279-6166
03/12/85	DUBUQUE MUNICIPAL AIRPORT	RR #3	DUBUQUE	IA 52001	ACE	NC	CLARK THERON N.	319-582-1715
03/04/85	IOWA CITY AIRPORT	1801 S. RIVERSIDE DR.	IOWA CITY	IA 52240	ACE	NC	ZEHR FRED	319-356-5045
03/05/85	DAVENPORT MUNICIPAL AIRPORT	RR#3	DAVENPORT	IA 52804	ACE	NC	HARPER CHARLES	319-326-7807
06/13/85	HUTCHINSON MUNICIPAL AIRPORT	P.O. BOX 1567	HUTCHINSON	KS 67504-1567	ACE	SC	BLACK JOE H.	316-662-9344
06/24/85	DODGE CITY MUNICIPAL AIRPORT	JET STAR ROUTE	DODGE CITY	KS 67801	ACE	SC	URBAN TERRY	316-225-1391
09/03/85	GARDEN CITY MUNICIPAL ARPT.	BOX 499 CITY HALL	GARDEN CITY	KS 67846	ACE	SC	DAWSON LEON A.	316-276-8263
06/10/85	RENNER FIELD		GOODLAND	KS 67735	ACE	SC	COLLETT JOHN	913-899-7531
06/03/85	FORBES FIELD		TOPEKA	KS 66619	ACE	SC	PRITCHETT CARL E.	913-862-2362
06/06/85	MANHATTAN MUNICIPAL AIRPORT	P.O. BOX 748	MANHATTAN	KS 66502	ACE	SC	THOMAS JIM	913-537-0056
06/06/85	LIBERAL MUNICIPAL AIRPORT		LIBERAL	KS 67901	ACE	SC	MORRIS ALAN	316-624-0101
06/10/85	WICHTA MID-CONTINENT AIRPORT	2173 AIR CARGO ROAD	WICHITA	KS 67209	ACE	SC	HENDERSON DUNCAN C.	316-946-4700

Table A1 (cont'd).

DATE	AIRPORT NAME	STREET	CITY	ST ZIP	FAA REG	AAAE REG	CONTACT	TELEPHONE
03/04/85	KANSAS CITY INT'L. AIRPORT	PO BOX 20047	KANSAS CITY	MO 64195	ACE	NC	BERGE FRED	816-243-5207
03/11/85	RICHARDS-GEBAUR AIRPORT(GVW)	104 MAXWELL	KANSAS CITY	MO 64147	ACE	NC	SEIFERS WAYNE	816-322-0001
03/01/85	SPRINGFIELD REGIONAL ARPT	RT. 6 BOX 384-15	SPRINGFIELD	MO 65803	ACE	NC	HANCIK ROBERT D.	417-869-7231
03/01/85	KANSAS CITY DOWNTOWN ARPT	400 RICHARDS ROAD	KANSAS CITY	MO 64116	ACE	NC	NOYALLIS EDWARD C.	816-471-4946
03/04/85	LAMBERT-ST. LOUIS INT'L ARPT	PO BOX 10212,LAMBERT STA.	ST. LOUIS	MO 63145	ACE	NC	FREUND RAY	314-426-8017
03/04/85	LEE BIRD FIELD	PO BOX 1517	NORTH PLATTE	NE 69103	ACE	NC	COOK JOAN A.	308-532-1900
03/11/85	KEARNEY MUNICIPAL AIRPORT	PO BOX 484	KEARNEY	NE 68847	ACE	NC	JOHNSON RODNEY A.	308-234-2318
03/04/85	ALLIANCE AIRPORT	PO DRAWER D	ALLIANCE	NE 69301	ACE	NC	BAUER WOLFGANG	308-762-5400
03/25/85	HALL COUNTY REGIONAL AIRPORT	ROUTE 3, BOX 45	GRAND ISLAND	NE 68801	ACE	NC	HINMAN HOWARD S.	308-381-5171
03/04/85	EPPLEY AIRFIELD	PO BOX 19103	OMAHA	NE 68164	ACE	NC	WUERTH M. R.	402-422-6800
03/01/85	BEATRICE MUNICIPAL ARPT.	BOX 277	BEATRICE	NE 68310	ACE	NC	FITZWATER DON	402-228-4585
03/19/85	WASHINGTON DULLES INT'L ARPT		WASHINGTON	DC 20041	AEA	NE	KIRKBRIDE FRANK	703-471-7015
03/06/85	WILMINGTON/NEW CASTLE CO.	151 N. DUPONT PARKWAY	NEW CASTLE	DE 19720	AEA	NE	ANGELINE DREW	302-323-2680
03/04/85	MONTGOMERY COUNTY AIRPORT	7940 AIRPORT DRIVE	GAITHERSBURG	MD 20879	AEA	NE	SPENCE CRAIG J.	301-977-0125
03/25/85	COLLEGE PARK AIRPORT	6709 CPL. FRANK SCOTT DR.	COLLEGE PARK	MD 20879	AEA	NE	BARNEY JOHN E.	301-864-5844
03/22/85	WASHINGTON CO. REG. AIRPORT	RT 8 BOX 228-A	HAGERSTOWN	MD 21740	AEA	NE	SPROWLS LEIGH	301-791-3333
03/08/85	BALT-WASH INT'L AIRPORT	PO BOX 8766	BWI AIRPORT	MD 21240	AEA	NE	RIORDAN DAN	301-859-7024
03/14/85	MORRISTOWN MUNICIPAL AIRPORT	AVCO SERVICES CORP.	MORRISTOWN	NJ 07960	AEA	NE	D'ALOISIO BRUCE	201-538-6400
03/04/85	TETERBORO AIRPORT	399 INDUSTRIAL AVE	TETERBORO	NJ 07608	AEA	NE	ENGLE PHILIP W.	201-288-1775

Table A1 (cont'd). Airport addresses and contacts.

DATE	AIRPORT NAME	STREET	CITY	ST ZIP	FAA REG	AAAE REG	CONTACT	TELEPHONE
03/04/85	ALANTIC CITY MUNICIPAL ARPT	PO BOX 550	POMONA	NJ 08240	AEA	NE	RAFTER THOMAS	609-645-7895
03/01/85	MERCER COUNTY AIRPORT	SCOTCH ROAD	WEST TRENTON	NJ 08628	AEA	NE	JONES BEN	609-882-1600
03/29/85	DUNKIRK MUNICIPAL AIRPORT	C/O CITY HALL	DUNKIRK	NY 14048	AEA	NE	DeLONG III HUGH K.	716-366-2967
02/27/85	CLINTON COUNTY AIRPORT	198 AIRPORT ROAD	PLATTSBURGH	NY 12901	AEA	NE	CONNOR BILL	518-565-4795
03/22/85	SULLIVAN COUNTY INT'L ARPT	PO BOX 27	WHITE LAKE	NY 12786	AEA	NE	BOSCH FREDERICK	914-794-3000
02/28/85	ADIRONDACK AIRPORT	RFD #1	SARANAC LAKE	NY 12983	AEA	NE	FINEGAN JOHN E.	518-891-4600
02/28/85	CHAUTAUQUA COUNTY AIRPORT	BOX 51	FALCONER	NY 14733	AEA	NE	BRENTLEY KENNETH	716-484-0204
02/28/85	OLEAN MUNICIPAL AIRPORT	MUNICIPAL BUILDING DPW	OLEAN	NY 14760	AEA	NE	MARCUS PETER	716-372-2200
03/01/85	BROOME CO. AIRPORT	BOX 16	JOHNSON CITY	NY 13790	AEA	NE	SUOMI DAVID C.	607-798-7171
03/04/85	TOMPKINS COUNTY AIRPORT	BROWN ROAD	ITHACA	NY 14850	AEA	NE	JOUBERT JOHN J.	607-257-0456
03/06/85	LOCKPORT AVIATION CENTER	6700 TRANSIT ROAD	LOCKPORT	NY 14094	AEA	NE	OLISLAGERS ROBERT	716-625-8111
03/14/85	LONG ISLAND MacARTHUR ARPT	100 ARRIVAL AVE.	RONKONKOMA	NY 11779	AEA	NE	ROSCHE' C. LEE	516-588-8062
03/14/85	ROCHESTER MONROE COUNTY ARPT	1200 BROOKS AVE.	ROCHESTER	NY 14624	AEA	NE	COOPER JR. S. A.	716-436-5624
03/19/85	ORANGE COUNTY AIRPORT	RD 2 BOX 13	MONTGOMERY	NY 12549	AEA	NE	MORINA J. A.	914-457-3106
04/08/85	NIAGARA FALLS INT'L AIRPORT	NIAGARA FALLS BLVD.	NIAGARA FALLS	NY 14304	AEA	NE	TOROMINO JOSEPH	716-297-4494
03/05/85	BUFFALO INT'L. AIRPORT		BUFFALO	NY 14225	AEA	NE	ZMUDA WALTER D.	716-855-7252
03/06/85	WARREN COUNTY AIRPORT	COUNTY LINE ROAD	GLENS FALLS	NY 12801	AEA	NE	AUSTIN FRED	518-623-4141
02/28/85	DUTCHESS COUNTY AIRPORT		WAPPINGERS FALLS	NY 12590	AEA	NE	WHITED BRADLEY S.	914-462-2600
03/07/85	BROOKHAVEN MUNICIPAL AIRPORT	DAWN DRIVE	SHIRLEY	NY 11967	AEA	NE	RAUH JOHN	516-281-5100

Table A1 (cont'd).

DATE	AIRPORT NAME	STREET	CITY	ST	ZIP	FAA REG	AAAE REG	CONTACT	TELEPHONE
03/04/85	SUFFOLK COUNTY AIRPORT		WESTHAMPTON BEAC	NY	11978	AEA	NE	LA TRENTA JOSEPH	516-288-3600
03/04/85	WESTMORLAND COUNTY AIRPORT	RD #1 BOX 386	LATROBE	PA	15650	AEA	NE	NASUTI ED	814-371-7750
03/05/85	JOHNSTOWN-CAMBRIA CO.AIRPORT	R.D. #2	JOHNSTOWN	PA	15904	AEA	NE	GENDAY RICK	814-472-7700
04/19/85	WILKES-BARRE/SCRANTON INT'L.		AVOCA	PA	18641	AEA	NE	KEMP ROBERT J.	717-457-5544
03/01/85	WASHINGTON COUNTY AIRPORT	RT. 185	WASHINGTON	PA	15301	AEA	NE	KNUPA KENNETH	412-228-6811
02/28/85	WILLIAMSPORT LYCOMING CO.	AIRPORT	MONTOURSVILLE	PA	17754	AEA	NE	BROWNLEE NELSON G.	717-368-2444
03/14/85	READING MUNICIPAL AIRPORT	RD 9, BOX 9416	READING	PA	19605-9606	AEA	NE	SROKA TERRY P.	215-372-4666
03/05/85	PITTSBURGH INT'L. AIRPORT	RM.134M TERMINAL BLDG.	PITTSBURGH	PA	15231	AEA	NE	ADAMS FRANK R.	412-778-2580
03/21/85	HARRISBURG INT'L AIRPORT	45 LUKE DRIVE, HIA	MIDDLETOWN	PA	17057	AEA	NE	STROUSE MR. FRAN	717-948-5068
06/05/85	HART FIELD		MORGANTOWN	WV	26505	AEA	SE	AIRPORT MANAGER	304-291-7461
06/06/85	WOOD COUNTY AIRPORT	P.O. BOX 4067	PARKERSBURG	WV	26104	AEA	SE	ALLEN RICHARD B.	304-464-5113
06/03/85	BENEDUM AIRPORT	ROUTE 2, BOX 699	BRIDGEPORT	WV	26330	AEA	SE	STEWART PAUL E.	304-842-3400
06/24/85	GREENBRIER VALLEY AIRPORT	P.O. BOX 329	LEWISBURG	WV	24901	AEA	SE	CRANE ROBERT C.	304-645-3961
06/06/85	TRI-STATE AIRPORT	1449 AIRPORT ROAD	HUNTINGTON	WV	25704	AEA	SE	SALYERS L. G.	304-453-2801
06/10/85	KANAWHA AIRPORT	CENTRAL WV REG ARPT AUTH	CHARLESTON	WV	25311	AEA	SE	HUFFMAN DANNY C.	304-344-8033
03/05/85	SOUTHERN ILLINOIS AIRPORT	RR #2	MURPHYSBORO	IL	62966	AGL	NC	WATERS VINCE	618-529-1721
03/05/85	MT. VERNON-OUTLAND AIRPORT	RR#4	MT. VERNON	IL	62864	AGL	NC	FIREBAUGH MAX C.	618-242-7016
03/05/85	MT. CARMEL AIRPORT		ST. FRANCISVILLE	IL	62460	AGL	NC	WOOD KEN	618-948-2413
03/18/85	ST. LOUIS REGIONAL AIRPORT	8 TERMINAL DR., SUITE 1	EAST ALTON	IL	62024	AGL	NC	MOON MICHAEL C.	618-259-2531

Table A1 (cont'd). Airport addresses and contacts.

DATE	AIRPORT NAME	STREET	CITY	ST ZIP	FAA REG	AAAE REG	CONTACT	TELEPHONE
03/25/85	GREATER KANKAKEE AIRPORT	RT. 1 BOX 168	KANKAKEE	IL 60901	AGL	NC	SKOREPA STEVEN C.	815-939-1422
03/06/85	LAWRENCEVILLE-VINCENNES INTL	R. R. 4 BOX 195	LAWRENCEVILLE	IL 62439	AGL	NC	ELLIOTT JIM	618-943-5733
03/01/85	VERMILION COUNTY AIRPORT	RR 6 BOX 331	DANVILLE	IL 61832	AGL	NC	GAGNON ROBERT	217-442-4624
03/04/85	UNIV. OF ILL.-WILLARD ARPT.		SAVOY	IL 61874	AGL	NC	MERRILL NICHOLAS C	217-333-3204
04/01/85	WILLIAMSON COUNTY	R 3 BOX 217 C	MARION	IL 62959	AGL	NC	STOKER CHARLES C.	618-993-2764
03/04/85	COLES CO. MEMORIAL AIRPORT	PO BOX 870	MATTOON	IL 61938	AGL	NC	COVALT MICHAEL A.	217-234-7120
03/05/85	DECATUR AIRPORT	AIRPORT ROAD	DECATUR	IL 62521	AGL	NC	SCHOWALTER ROBERT J.	217-428-2423
03/12/85	ST.LOUIS DWNTWN. PARKS ARPT.	10 ARCHVIEW DR.	CAHOKIA	IL 62206	AGL	NC	MOLLA GENE	618-337-6060
02/28/85	MONROE COUNTY AIRPORT	972 S. KIRBY ROAD	BLOOMINGTON	IN 47401	AGL	NC	BOONE COL. G. T.	812-825-5406
03/01/85	ELKHART MINICIPAL AIRPORT	PO BOX 1212	ELKHART	IN 46515	AGL	NC	COBB JAMES G.	219-264-5271
03/11/85	BAER FIELD AIRPORT	RM209 BAER FIELD TERMINAL	FT. WAYNE	IN 46809	AGL	NC	MILLER SKIP	219-747-4146
03/14/85	EVANSVILLE DRESS REG. ARPT	6001 FLIGHT LINE ROAD	EVANSVILLE	IN 47711	AGL	NC	WORKING BOB	812-424-5511
03/22/85	INDIANAPOLIS INT'L AIRPORT	2500 S. HIGH SCHOOL ROAD	INDIANAPOLIS	IN 46251	AGL	NC	HALL JIM	317-248-9594
03/01/85	PURDUE UNIVERSITY AIRPORT	TERMINAL 221	WEST LAFAYETTE	IN 47906	AGL	NC	STROUD ROBERT D.	317-743-3442
03/01/85	MICHIANA REGIONAL AIRPORT	4535 TERMINAL DRIVE	SOUTH BEND	IN 46628	AGL	NC	SCHALLIOL JOHN	219-233-2185
02/27/85	BISHOP INT'L. AIRPORT	G-3425 WEST BRISTOL	FLINT	MI 48507	AGL	NC	BENNETT JAMES E.	313-767-4232
02/28/85	EMMET COUNTY AIRPORT	US-31N	PELLSTON	MI 49769	AGL	NC	THOMPSON RAY	616-534-8441
02/28/85	MUSKEGON COUNTY AIRPORT	99 SINCLAIR DRIVE	MUSKEGON	MI 49441	AGL	NC	GREVIOUS TERRY	616-798-4596
03/05/85	W. K. KELLOGG REG. AIRPORT	RM. 200 TERM. BLDG.	BATTLE CREEK	MI 49015	AGL	NC	THURSTON DAN	616-966-3470

Table A1 (cont'd).

DATE	AIRPORT NAME	STREET	CITY	ST	ZIP	FAA REG	AAAE REG	CONTACT	TELEPHONE
03/01/85	ST.CLAIR CO. INT'L. ARPT.	21 AIRPORT DRIVE	PORT HURON	MI	48060	AGL	NC	HAVENS DUANE I.	313-364-6890
03/01/85	JACKSON COUNTY AIRPORT	3606 WILDWOOD AVE.	JACKSON	MI	49202	AGL	NC	COLLER RANDY L.	517-788-4225
04/17/85	HOUGHTON COUNTY AIRPORT	ROUTE 1	CALUMET	MI	49913	AGL	NC	HAGMAN ARTHUR B.	906-482-3970
06/06/85	DELTA COUNTY AIRPORT	3300 AIRPORT ROAD	ESCANABA	MI	49829	AGL	NC	SETTER HARVEY	906-786-9037
02/27/85	TWIN CITIES AIRPORT	1123 TERRITORIAL RD.	BENTON HARBOR	MI	49022	AGL	NC	RHODES DAVID	616-927-3194
03/04/85	KALAMAZOO COUNTY AIRPORT	5235 PORTAGE RD.	KALAMAZOO	MI	49002	AGL	NC	MILLER MICHAEL	616-345-1032
04/11/85	CHERRY CAPITAL AIRPORT	AIRPORT ACCESS ROAD	TRAVERSE CITY	MI	49684	AGL	NC	CASSENS STEPHEN R.	616-947-2250
06/07/85	GOGEBIC COUNTY AIRPORT	AIRPORT ROAD	IRONWOOD	MI	49938	AGL	NC	BRASPENICK JOE	906-932-3121
03/01/85	KENT COUNTY INT'L. AIRPORT	5500 44TH STREET SE.	GRAND RAPIDS	MI	49508	AGL	NC	PEDERSON HAROLD	616-949-4500
02/27/85	TRI CITY AIRPORT	PO BOX P	FREELAND	MI	48623	AGL	NC	VanBEEST DENNIS	517-695-5555
03/06/85	CAPITAL CITY AIRPORT		LANSING	MI	48906	AGL	NC	OTTO DANIEL J.	517-321-6121
03/01/85	DETROIT METRO. AIRPORT		DETROIT	MI	48242	AGL	NC	GARVIN JOHN	313-942-3685
03/05/85	CHIPPEWA COUNTY AIRPORT	119 CULLEY	KINCHELOE	MI	49788	AGL	NC	SHORT L. JACK	906-495-5656
03/04/85	ROCHESTER MUNICIPAL AIRPORT	ROCHESTER AIRPORT CO.	ROCHESTER	MN	55902	AGL	NC	LEQVE STEVEN W.	507-282-2328
03/22/85	MINNEAPOLIS-ST PAUL INT'L.	PO BOX 1700	ST. PAUL	MN	55111	AGL	NC	FINNEY NIGEL	612-726-1892
03/01/85	MINOT INT'L. AIRPORT		MINOT	ND	58701	AGL	NC	PETERSEN C. H.	701-857-4724
03/04/85	SLOULIN FIELD INT'L. ARPT.	PO BOX 1306	WILLISTON	ND	58801	AGL	NC	OLSON JERRY	701-774-8594
03/11/85	INT'L PEACE GARDEN AIRPORT	N.D. AERO. COMM. BOX 5020	BISMARK	ND	58502	AGL	NC	HOLZER MARK	701-224-4747
02/28/85	GRAND FORKS INT'L. ARPT.	RR #2	GRAND FORKS	ND	58201	AGL	NC	BRETON THOMAS	701-775-6293

Table A1 (cont'd). Airport addresses and contacts.

DATE	AIRPORT NAME	STREET	CITY	ST ZIP	FAA REG	AAAE REG	CONTACT	TELEPHONE
03/07/85	BISMARCK MUNICIPAL AIRPORT	P.O. BOX 991	BISMARCK	ND 58502	AGL	NC	HEINEMEYER RAY	701-222-6502
03/04/85	HECTOR INT'L. AIRPORT	PO BOX 2845	FARGO	ND 58108	AGL	NC	PARMER JOSEPH	701-237-0727
03/11/85	LORAIN CO. REGIONAL AIRPORT	44050 RUSSIA RD.	ELYRIA	OH 44035	AGL	NC	DANCIK ROBERT J.	216-323-4063
03/19/85	KENT STATE UNIVERSITY ARPT.	4020 KENT ROAD	STOW	OH 44224	AGL	NC	RIPPLE E. G.	216-672-2640
07/17/85	TOLEDO EXPRESS AIRPORT	11013 AIRPORT HWY	SWANTON	OH 43558	AGL	NC	RINEHART JOHN C.	419-865-2351
04/15/85	OHIO STATE UNIV. AIRPORT	BOX 3022	COLUMBUS	OH 43210	AGL	NC	NEWSTROM K. R.	614-422-5460
03/01/85	DAYTON INT'L. AIRPORT	RM 304 TERMINAL BUILDING	VANDALIA	OH 45377	AGL	NC	WOOD J. R.	513-898-4631
03/04/85	CINCINNATI INT'L. AIRPORT	PO BOX 752000	CINCINNATI	OH 45275	AGL	NC	KEEFE ROBERT A.	606-283-3166
03/05/85	RICKENBACKER AIRPORT	400 S. FRONT ST.	COLUMBUS	OH 43215	AGL	NC	WALDRON ERIC N.	614-461-9046
03/25/85	LUNKEN MUNICIPAL AIRPORT	262 WILMER AVENUE	CINCINNATI	OH 45226	AGL	NC	KENNY EDWARD T.	513-321-4132
04/01/85	BOLTON FIELD	2000 NORTON ROAD	COLUMBUS	OH 43228	AGL	NC	DOONAN T. ALAN	614-878-8372
03/11/85	AIRBORNE AIRPARK	145 HUNTER DR.	WILMINGTON	OH 45177	AGL	NC	THUMMA JIM	513-382-5591
03/27/85	CUYAHOGA COUNTY AIRPORT	355 RICHMOND ROAD	CLEVELAND	OH 44143	AGL	NC	SHEA ROBERT D.	216-261-1066
02/28/85	JOE FOSS FIELD		SIOUX FALLS	SD 57104	AGL	NC	ORR JOHN G.	605-336-0762
03/04/85	WATERTOWN MUNICIPAL AIRPORT		WATERTOWN	SD 57201	AGL	NC	LETZE BERNARD	605-886-2265
03/04/85	RAPID CITY REGIONAL AIRPORT	RT.2 BOX 4640	RAPID CITY	SD 57701	AGL	NC	HANSEN ERNEST W.	605-394-4195
03/11/85	DOOR COUNTY AIRPORT	3418 PARK DRIVE	STURGEON BAY	WI 54235	AGL	NC	McQUEEN GEORGE	414-743-3636
02/28/85	LaCROSSE MUNICIPAL ARPT.	2840 FANTA-REED ROAD	LaCROSSE	WI 54603	AGL	NC	HAATAJA DUANE R.	608-782-5027
03/01/85	DANE CO. REGIONAL AIRPORT	4000 INTERNATIONAL LANE	MADISON	WI 53704	AGL	NC	KOSLOSKY JIM	608-266-4595

Table A1 (cont'd).

DATE	AIRPORT NAME	STREET	CITY	ST ZIP	FAA REG	AAAE REG	CONTACT	TELEPHONE
03/05/85	RHINELANDER-ONEIDA CO. ARPT.	3375 AIRPORT RD.	RHINELANDER	WI 54501	AGL	NC	CHMIEL JOHN E.	715-362-3641
03/18/85	EAU CLAIRE COUNTY AIRPORT	3800 STARR AVE.	EAU CLAIRE	WI 54703	AGL	NC	WRIGHT BURT	715-839-4900
03/04/85	GENERAL MITCHELL FIELD	5300 S. HOWELL AVE	MILWAUKEE	WI 53207	AGL	NC	McALEESE TOM	414-747-5321
02/14/85	CENTRAL WISCONSIN AIRPORT	823-1 HWY 153	MOSINEE	WI 54455-9601	AGL	NC	HANSFORD JAMES	715-693-2147
02/28/85	OUTAGAMIE COUNTY AIRPORT	RR #6	APPLETON	WI 54915	AGL	NC	BORCHARDT ARTHUR E.	414-735-5268
03/04/85	TWEED - NEW HAVEN AIRPORT	ADMIN.BLDG 2 FLR,BURR ST.	NEW HAVEN	CT 06512	ANE	NE	STINCHFIELD DUANE	203-787-8285
06/06/85	DANBURY MUNICIPAL AIRPORT	P.O. BOX 2299,WEIBLING RD	DANBURY	CT 06810-2299	ANE	NE	ESTEFAN PAUL D.	203-797-4624
02/27/85	GROTON NEW LONDON AIRPORT	TOWER AVE.	GROTON	CT 06340	ANE	NE	LITTLE ERNEST J.	203-445-8549
03/01/85	NEW BEDFORD MUNICIPAL ARPT	SHAWMUT AVE	NEW BEDFORD	MA 02746	ANE	NE	EISNER ISIDORE	617-992-2264
03/05/85	PLYMOUTH MUNICIPAL AIRPORT	S. MEADOW RD.	PLYMOUTH	MA 02360	ANE	NE	SMITH WARREN	617-746-2020
03/04/85	BEVERLY MUNICIPAL AIRPORT	HENDERSON RD	BEVERLY	MA 01915	ANE	NE	CHAPMAN GREGORY	617-922-4280
02/28/85	WORCESTER MUNICIPAL ARPT.	375 AIRPORT DRIVE	WORCESTER	MA 01602	ANE	NE	TRAINOR ROBERT J.	617-757-1900
04/08/85	LOGAN INTERNATIONAL AIRPORT		EAST BOSTON	MA 02128	ANE	NE	DAVIS JOHN R.	617-973-5338
03/25/85	HANSCOM FIELD (AFB)	CIVIL TERMINAL-MASSPORT	BEDFORD	MA 01730	ANE	NE	HIDINGER FRANK	617-274-7200
03/28/85	AUBURN-LEWISTON MUN. AIRPORT	TERMINAL BUILDING, R-4	AUBURN	ME 04210	ANE	NE	GONGOLL JEFFREY A.	207-786-0631
07/15/85	KNOX COUNTY AIRPORT	P.O. BOX 686	ROCKLAND	ME 04841	ANE	NE	DANFORTH JIM	207-594-4131
03/01/85	SANFORD MUNICIPAL AIRPORT	267 MAIN STREET	SANFORD	ME 04073	ANE	NE	DEMERS PAUL A.	207-324-4910
03/18/85	LEBANON MUNICIPAL AIRPORT		WEST LEBANON	NH 03784	ANE	NE	THEBERGE MARCEL J.	603-298-8878
03/05/85	MANCHESTER AIRPORT	MANCHESTER ARPT ATHORITY	MANCHESTER	NH 03103	ANE	NE	CUSHING EARL H.	603-624-6541

Table A1 (cont'd). Airport addresses and contacts.

DATE	AIRPORT NAME	STREET	CITY	ST ZIP	FAA REG	AAAE REG	CONTACT	TELEPHONE
03/05/85	T.F. GREEN STATE AIRPORT		WARWICK	RI 02886	ANE	NE	BAKER MEL	401-737-4000
03/06/85	BURLINGTON INT'L. AIRPORT	BOX 1 AIRPORT DRIVE	S. BURLINGTON	VT 05401	ANE	NE	HOUGHTON WALTER E.	802-863-2874
03/08/85	WALKER FIELD AIRPORT		GRAND JUNCTION	CO 81501	ANM	NW	BOGGS MIKE	303-244-9120
05/02/85	COLORADO SPRINGS MUNICIPAL	5750 E. FOUNTAIN BLVD.	COLORADO SPRINGS	CO 80916	ANM	NW	STRICKER EDWARD	303-596-0188
06/10/85	PITKIN COUNTY AIRPORT	20292 HIGHWAY 82	ASPEN	CO 81611	ANM	NW	FROME BILL	303-925-8698
03/07/85	PUEBLO MEMORIAL AIRPORT	31475 BRYAN CIRCLE	PUEBLO	CO 81001	ANM	NW	MONROE RAYMOND	303-948-3355
03/01/85	DURANGO-LaPLATA CO. ARPT.	P.O. BOX 2677	DURANGO	CO 81302	ANM	NW	ALLISON C. ROBERT	303-247-8413
03/01/85	MONTROSE COUNTY AIRPORT	POBOX 997,1450 AIRPORT RD	MONTROSE	CO 81402	ANM	NW	KARL DAVID E.	303-249-3203
03/04/85	YAMPA VALLEY REG. AIRPORT	PO BOX N,11005ROUTT CR51A	HAYDEN	CO 81639	ANM	NW	VIALPANDO MICHAEL	303-276-3669
03/05/85	JEFFERSON COUNTY AIRPORT	TERMINAL BLDG. B-7	BROOMFIELD	CO 80020	ANM	NW	LOHNE BOB	303-466-2314
06/04/85	ANIMAS AIR PARK	PO BOX 1797	DURANGO	CO 81301	ANM	NW	GREGG JIM	303-247-4632
06/24/85	CORTEZ-MONTEZUMA CO. AIRPORT	C/O CITY HALL, 210 E MAIN	CORTEZ	CO 81321	ANM	NW	SANFILIPPO SUSAN M.	303-565-3402
07/10/85	STAPLETON INTERNATIONAL ARPT		DENVER	CO 80207	ANM	NW	BRENNAN JACK	303-398-3849
03/01/85	BOISE AIR TERMINAL	3201 AIRPORT WAY	BOISE	ID 83705	ANM	NW	ANDERSON JOHN	208-383-3110
03/04/85	IDAHO FALLS MUNICIPAL ARPT		IDAHO FALLS	ID 83402	ANM	NW	THORSEN JAMES M.	208-529-1221
03/01/85	LEWISTON-NEZ PERCE CO. ARPT.		LEWISTON	ID 83501	ANM	NW	TURNER ROBIN	208-746-7962
03/01/85	BILLINGS LOGAN INT'L. ARPT.		BILLINGS	MT 59105	ANM	NW	BINFORD TOM	406-657-8495
03/04/85	HELENA REGIONAL AIRPORT	2850 SKYWAY DR.	HELENA	MT 59001	ANM	NW	MERCER RON	406-442-2821
03/11/85	RAVALLI COUNTY AIRPORT	PO BOX 42	HAMITON	MT 59840	ANM	NW	REIF JOSEPH R.	406-363-4737

Table A1 (cont'd).

DATE	AIRPORT NAME	STREET	CITY	ST ZIP	FAA REG	AAAE REG	CONTACT	TELEPHONE
03/01/85	BERT MOONEY AIRPORT		BUTTE	MT 59701	ANM	NW	PETRONI ANGELO	406-494-3771
03/04/85	GALLATIN FIELD	BOX 146	BOZEMAN	MT 59715	ANM	NW	MATHIS TED	406-388-6632
03/20/85	GREAT FALLS INT'L AIRPORT	ROUTE 4028	GREAT FALLS	MT 59401-9583	ANM	NW	FERDA JERRY	406-727-3404
03/18/85	MISSOULA COUNTY AIRPORT	5525 HIGHWAY 10 WEST	MISSOULA	MT 59802	ANM	NW	PANKEY RUSS	406-728-4381
03/05/85	SEELEY LAKE AIRPORT	PO BOX 491	SEELEY LAKE	MT 59868	ANM	NW	LINDEMER GRANT G.	406-677-9229
06/07/85	MAHLON SWEET FIELD	90550 GREENHILL ROAD	EUGENE	OR 97402	ANM	NW	SHELBY R. W.	503-687-5430
06/10/85	REDMOND MUNICIPAL AIRPORT	455 S. 7TH STREET	REDMOND	OR 97756	ANM	NW	ZIMMER JERRY	503-548-1023
06/13/85	PORTLAND INTERNATIONAL ARPT.	7000 N.E. AIRPORT WAY	PORTLAND	OR 97218	ANM	NW	GATTO ANTHONY	503-231-5000
06/24/85	MEDFORD-JACKSON COUNTY ARPT.	3650 BIDDLE ROAD	MEDFORD	OR 97504	ANM	NW	KATZMAR G. E.	503-776-7221
06/06/85	NORTH BEND MUNICIPAL AIRPORT	P.O. BOX B	NORTH BEND	OR 97459	ANM	NW	STILLMAKER RON	503-756-0416
07/29/85	LOGAN/CACHE AIRPORT	170 N. MAIN	LOGAN	UT 84321	ANM	SW	NELSON KEITH J.	801-752-5935
06/24/85	CEDAR CITY MUNICIPAL ARPT.		CEDAR CITY	UT 84720	ANM	SW	HARDING CLYDE	801-586-3881
06/07/85	SALT LAKE CITY	AMF BOX 22084	SALT LAKE CITY	UT 84122	ANM	SW	HUNTZINGER HAROLD	801-539-2900
03/01/85	FAIRCHILD INT'L. AIRPORT	P.O. BOX 1350	PORT ANGELES	WA 98362	ANM	NW	CONLEY J. W.	206-457-8527
03/05/85	CHELAN-DOUGLAS CO. REG. ARPT	PO BOX 1762	WENATCHEE	WA 98801	ANM	NW	CLARKE COLIN	509-884-2494
03/04/85	YAKIMA AIR TERMINAL	2300 WEST WASHINGTON AVE	YAKIMA	WA 98903	ANM	NW	KILPATRICK JERRY	509-575-6149
03/05/85	TRI-CITIES AIRPORT	3601 N. 20th AVENUE	PASCO	WA 99301	ANM	NW	MORASCH JIM	509-547-6352
03/01/85	SPOKANE INT'L. AIRPORT	PO BOX 19186	SPOKANE	WA 99219-9186	ANM	NW	BELL ED	509-624-3218
03/01/85	SNOHOMISA CO. AIRPORT		EVERETT	WA 98204	ANM	NW	JACKETS M. E.	206-353-2110

Table A1 (cont'd). Airport addresses and contacts.

DATE	AIRPORT NAME	STREET	CITY	ST ZIP	FAA REG	AAAE REG	CONTACT	TELEPHONE
03/04/85	KING COUNTY INT'L. AIRPORT	PO BOX 80245	SEATTLE	WA 98108	ANM	NW	WINTER JEFF	206-344-7380
03/05/85	SEA-TAC INT'L. AIRPORT		SEATTLE	WA 98188	ANM	NW	KRAUSE ART	206-433-5410
03/05/85	GRANT COUNTY AIRPORT	TERMINAL BLDG 1202	MOSES LAKE	WA 98837	ANM	NW	BAILEY DAVID M.	509-762-5363
02/28/85	WORLAND MUNICIPAL AIRPORT	1472 AIRPORT RD. BOX 606	WORLAND	WY 82401	ANM	NW	NEHL JOE	307-347-3616
03/05/85	ROCK SPRINGS-SWEETWATER ARPT	PO BOX 1965	ROCK SPRINGS	WY 82902	ANM	NW	VALENTINE GARY D.	307-382-4580
03/06/85	JACKSON HOLE AIRPORT	BOX 159	JACKSON	WY 83001	ANM	NW	LEWIS CAROL	307-733-7682
03/04/85	CHEYENNE AIRPORT	PO BOX 2063	CHEYENNE	WY 82003	ANM	NW	WOOD JOHN	307-634-7071
06/06/85	BARKLEY REGIONAL AIRPORT	P.O. BOX 1131	PADUCAH	KY 42002	ASO	SE	ROOF RICHARD	502-442-0521
06/10/85	OWENSBORO-DAVIESS CO. ARPT.	P.O. BOX 1913	OWENSBORO	KY 42302	ASO	SE	GAMES JOHN R.	502-685-4179
06/06/85	PULLIAM AIRPORT	211 W. ASPEN AVE.	FLAGSTAFF	AZ 86001	AWP	SW	LARKIN G. LARRY	602-774-1422
08/05/85	PRESCOTT MUNICIPAL AIRPORT	P.O. BOX 2059	PRESCOTT	AZ 86302	AWP	SW	MORRISON JIM	602-445-7860
06/24/85	WINSLOW MUNICIPAL AIRPORT	HC 62, P.O. BOX 150	WINSLOW	AZ 86047	AWP	SW	CARLSON GARY	602-289-2429
06/24/85	REDDING MUNICIPAL AIRPORT	760 PARKVIEW AVE.	REDDING	CA 96001	AWP	SW	HOMAN H. A.	916-225-4120
06/10/85	MEADOWS FIELD	1401 SKYWAY DRIVE	BAKERSFIELD	CA 93308-1697	AWP	SW	AVERY JERRY	805-393-7990
06/10/85	SISKIYOU COUNTY AIRPORT	800 S. MAIN STREET	YREKA	CA 96097	AWP	SW	STEWART BLAIR	916-842-3531
06/24/85	CHICO MUNICIPAL AIRPORT	196 E. 5TH ST. (BOX 3420)	CHICO	CA 95927	AWP	SW	BRANDLEY R. W.	916-922-4725

APPENDIX B: SUMMARY LISTING OF QUESTIONNAIRE RESPONSES.

TYPES OF PAVEMENTS AND THEIR CONDITIONS
INCLUDES: SURFACE RATINGS, FREEZE/THAW PROBLEMS,
AND PROBLEMS DURING WET SEASONS.

FAA REG	AAAE REG	ST	CODE	C. TYPE PAVT	D. NEW CON	E.1 RUN COND	E.2 TAXI COND	E.3 PARK COND	F.1 THAW WATER	F.2 RAIN WATER	G.1 THAW DEB	G.2 RAIN DEB	H. ROUGH COND	I. REFLECTION CRACKING	J. GENERAL PROBLEMS ENCOUNTERED
AAL	NW	AK	080	AC	YES	FAIR	FAIR	FAIR	NO	NO	NO	NO	YES	NO	MAINTAINING LIGHTING
AAL	NW	AK	126	AC	YES	FAIR	FAIR	GOOD	NO	NO	NO	NO	NO	NO OVERLAY	DEBRIS AND CRACKS DUE TO COLD TEMPERATURES
AAL	NW	AK	118	AC	YES	GOOD	GOOD	EX/F	NO	NO	NO	NO	NO	NO	REMOVING SMALL ICE PATCHE
ACE	NC	IA	103	AC	YES	GOOD	GOOD	GOOD	NO	NO	NO	NO	NO	YES	
ACE	NC	IA	100	BOTH	YES	G/F	GOOD	GOOD	YES	YES	YES	YES	YES	YES	CRACKS
ACE	NC	IA	013	BOTH	NO	GOOD	GOOD	FAIR	YES	YES	YES	YES	YES	YES	MAINTAINING LIGHTING DEBRIS CAUSED BY HEAVING
ACE	NC	IA	014	BOTH	YES	GOOD	GOOD	GOOD	NO	NO	NO	NO	NO	NO	
ACE	NC	IA	073	BOTH	YES	GOOD	GOOD	GOOD	YES	NO	YES	YES	YES	YES	SPALLING PCC
ACE	NC	IA	130	BOTH	YES	GOOD	GOOD	GOOD	NO	NO	YES	?	NO	YES	MAINTAINING LIGHTS/SIGNS
ACE	NC	IA	060	PCC	YES	FAIR	FAIR	GOOD	YES	YES	YES	YES	YES	NO OVERLAY	WATER DRAINAGE
ACE	NC	IA	084	PCC	YES	GOOD	GOOD	GOOD	NO	NO	NO	NO	NO	NO OVERLAY	MAINTAINING LIGHTING
ACE	SC	KS	192	AC	YES	FAIR	FAIR	FAIR	YES		YES		YES	YES	
ACE	SC	KS	199	AC	YES	FAIR	FAIR	POOR	YES	YES	NO	NO	YES	YES	REMOVAL OF ICE
ACE	SC	KS	206	AC	YES	GOOD	FAIR	GOOD	NO	NO	NO	NO	NO	YES	
ACE	SC	KS	185	BOTH	YES	EXC.	GOOD	EXC.	NO	NO	NO	NO	YES	NO OVERLAY	
ACE	SC	KS	168	BOTH	YES	GOOD	GOOD	F/P	YES	YES	YES	YES	YES	YES	DEBRIS REMOVAL
ACE	SC	KS	171	BOTH	YES	GOOD	GOOD	FAIR	YES	NO	YES	YES	NO	YES	MAINTAINING LIGHTING
ACE	SC	KS	172	BOTH	NO	GOOD	GOOD	GOOD	YES	YES	YES	YES	NO	YES	FREEZE THAW CYCLE
ACE	SC	KS	186	PCC	YES	FAIR	FAIR	POOR	YES	YES	YES	YES	YES	NO OVERLAY	MAINTAINING LIGHTING
ACE	NC	MO	071	BOTH	YES	EXC.	GOOD	GOOD	YES	YES	YES	YES	YES	YES	SPALLING PCC SLAB CORNERS LOSS PAVT SUBGRD SUPPORT
ACE	NC	MO	129	BOTH	YES	FAIR	FAIR	POOR	YES	YES	NO	NO	YES	NO OVERLAY	DEBRIS
ACE	NC	MO	026	BOTH	YES	GOOD	GOOD	FAIR	NO	NO	YES	YES	NO	YES	SPALLING
ACE	NC	MO	027	BOTH	YES	GOOD	GOOD	FAIR	YES	NO	YES	YES	YES	YES	POT-HOLES A FOD HAZARD MAINTAINING LIGHTING
ACE	NC	MO	083	PCC	YES	EXC.	EXC.	F/P	YES	YES	YES	YES	NO	NO	SPALLING

TYPES OF PAVEMENTS AND THEIR CONDITIONS
INCLUDES: SURFACE RATINGS, FREEZE/THAW PROBLEMS,
AND PROBLEMS DURING WET SEASONS.

FAA REG	AAAE REG	ST	CODE	C. TYPE PAVT	D. NEW CON	E.1 RUN COND	E.2 TAXI COND	E.3 PARK COND	F.1 THAW WATER	F.2 RAIN WATER	G.1 THAW DEB	G.2 RAIN DEB	H. ROUGH COND	I. REFLECTION CRACKING	J. GENERAL PROBLEMS ENCOUNTERED
ACE	NC	NE	055	BOTH	YES	EX/P	EXC.	EXC.	YES	YES	YES	?	NO	YES	
ACE	NC	NE	127	BOTH	YES	EXC.	EXC.	GOOD	YES	YES	NO	NO	NO	YES	SNOW REMOVAL
ACE	NC	NE	065	BOTH	NO	FAIR	FAIR	POOR	YES	NO	YES	NO	YES	YES	CRACK FILLING
ACE	NC	NE	151	BOTH	NO	GOOD	GOOD	FAIR	YES	NO	YES	NO	NO	YES	
ACE	NC	NE	059	PCC	YES	FAIR	GOOD	FAIR	YES	YES	YES	YES	YES	YES	DEBRIS FROM REFLEC-CRACKS
ACE	NC	NE	031	PCC	YES	GOOD	GOOD	GOOD	NO	NO	NO	NO	NO	YES	SEEPAGE ON HOT SUMMER DAY
AEA	NE	DC	141	PCC	YES	GOOD	GOOD	GOOD	YES	YES	YES	YES	NO	NO OVERLAY	SAND REMOVAL
AEA	NE	DE	112	AC	YES	GOOD	GOOD	FAIR	NO	NO	NO	NO	NO	NO	REMAINING FROZEN PATCHES
AEA	NE	MD	063	AC	NO	GOOD	FAIR	POOR	YES	YES	YES	YES	YES	YES	SINK HOLE IN R/W
AEA	NE	MD	154	AC	YES	GOOD	FAIR	POOR	NO	NO	NO	NO	YES	NO OVERLAY	FACILITY DRAINAGE
AEA	NE	MD	148	BOTH	YES	E/F	GOOD	GOOD	NO	NO	YES	YES	NO	NO	SNOW BANK REMOVAL
AEA	NE	MD	119	BOTH	YES	FAIR	FAIR	POOR	NO	NO	YES	YES	NO	YES	
AEA	NE	NJ	133	AC	YES	GOOD	FAIR	FAIR	YES	NO	YES	NO	NO	YES	HEAVING ELEC. CONDUITS DEBRIS FROM PAVT BREAK-UP
AEA	NE	NJ	058	AC	YES	POOR	FAIR	GOOD	NO	NO	YES	YES	NO	YES	
AEA	NE	NJ	066	BOTH	YES	EXC.	GOOD	FAIR	NO	NO	YES	NO	YES	NO OVERLAY	DEBRIS REMOVAL
AEA	NE	NJ	042	BOTH	YES	GOOD	GOOD	EXC.	YES	NO	YES	NO	NO	NO	
AEA	NE	NY	157	AC	YES	EX/G	G/P	GOOD	YES	YES	NO	NO	NO	NO OVERLAY	MAINTAINING LIGHTING FROST ACTION/PLOW DAMAGE
AEA	NE	NY	004	AC	YES	EX/P	FAIR	FAIR	NO	NO	YES	YES	NO	NO OVERLAY	CRACKING
AEA	NE	NY	147	AC	NO	FAIR	FAIR	FAIR	NO	NO	NO	NO	NO	NO OVERLAY	SLURRY SEAL 1985 MAINTAINING LIGHTS
AEA	NE	NY	011	AC	YES	GOOD	EXC.	EXC.	YES	YES	YES	YES	YES	YES	MAINTAINING LIGHTING
AEA	NE	NY	015	AC	YES	GOOD	GOOD	GOOD	YES	YES	YES	YES	YES	YES	
AEA	NE	NY	022	AC	NO	GOOD	GOOD	FAIR	NO	NO	NO	NO	NO	YES	HEAVY ICE
AEA	NE	NY	047	AC	YES	GOOD	GOOD	GOOD	NO	NO	NO	NO	NO	YES	
AEA	NE	NY	082	AC	YES	GOOD	GOOD	POOR	YES	YES	YES	YES	YES	YES	BRAKING COND. REPORTING

TYPES OF PAVEMENTS AND THEIR CONDITIONS
INCLUDES: SURFACE RATINGS, FREEZE/THAW PROBLEMS,
AND PROBLEMS DURING WET SEASONS.

FAA REG	AAAE REG	ST	CODE	C. TYPE PAVT	D. NEW CON	E.1 RUN COND	E.2 TAXI COND	E.3 PARK COND	F.1 THAW WATER	F.2 RAIN WATER	G.1 THAW DEB	G.2 RAIN DEB	H. ROUGH COND	I. REFLECTION CRACKING	J. GENERAL PROBLEMS ENCOUNTERED
AEA	NE	NY	110	AC	YES	GOOD	GOOD	GOOD	NO	NO	NO	NO	NO	NO	RECENTLY REPAVED ALL FLOODING OF RUNWAY
AEA	NE	NY	134	AC	NO	GOOD	GOOD	GOOD	NO	NO	YES	NO	NO	YES	
AEA	NE	NY	132	BOTH	YES	EXC.	GOOD	GOOD	YES	YES	NO	NO	YES	NO	ICE BUILD-UP AROUND C/L LIGHTS
AEA	NE	NY	142	BOTH	YES	FAIR	FAIR	GOOD	YES	NO	YES	YES	YES	NO OVERLAY	CRACKS/DIFFERENTIAL HEAVE
AEA	NE	NY	160	BOTH	YES	FAIR	FAIR	FAIR	NO	NO	YES	NO	NO	NO	BARRIER PROBLEMS
AEA	NE	NY	105	BOTH	YES	G/F	GOOD	EXC.	NO	NO	YES	NO	YES	YES	MAINTAINING LIGHTING
AEA	NE	NY	111	BOTH	YES	G/F	EXC.	FAIR	YES	NO	YES	NO	NO	YES	MAINTAINING LIGHTING
AEA	NE	NY	009	BOTH	YES	GOOD	FAIR	F/G	NO	NO	YES	NO	NO	YES	
AEA	NE	NY	115	BOTH	YES	GOOD	GOOD	GOOD	NO	NO	YES	NO	NO	NO OVERLAY	
AEA	NE	NY	064	PCC	YES	G/P	GOOD	GOOD	NO	NO	YES	YES	NO	NO OVERLAY	CRACKING
AEA	NE	PA	069	AC	YES	EXC.	EXC.	GOOD	NO	NO	NO	NO	NO	YES	A/C SEALCOAT MAIN APRON
AEA	NE	PA	104	AC	NO	EXC.	EXC.	EXC.	NO	NO	NO	NO	NO	YES	DRIFTING SNOW
AEA	NE	PA	165	AC	YES	EXC.	EXC.	EXC.	NO	NO	NO	NO	NO	YES	COLD WEATHER PATCHING MAT CRACKS ENLARGING
AEA	NE	PA	032	AC	YES	FAIR	FAIR	FAIR	NO	NO	NO	NO	YES	NO OVERLAY	
AEA	NE	PA	018	BOTH	YES	EXC.	GOOD	GOOD	YES	NO	NO	NO	YES	YES	CRACKS INC. IN SIZE
AEA	NE	PA	136	BOTH	NO	FAIR	FAIR	POOR	YES	YES	YES	YES	YES	NO OVERLAY	SAND REMOVAL FROM GROOVES
AEA	NE	PA	087	BOTH	YES	GOOD	GOOD	GOOD	NO	NO	YES	NO	NO	YES	PAVT. PATCHING / REPAIR
AEA	NE	PA	145	PCC	YES	EXC.	GOOD	GOOD	NO	NO	YES	YES	NO	NO OVERLAY	DEBRIS DAMAGE
AEA	SE	WV	170	AC	YES	EXC.	GOOD	FAIR	NO	NO	NO	NO	NO	YES	
AEA	SE	WV	173	AC	NO	EXC.	EXC.	GOOD	YES	YES	YES	YES	NO	YES	
AEA	SE	WV	167	AC	YES	FAIR	FAIR	GOOD	YES	YES	YES	YES	NO	NO	EQUIPMENT
AEA	SE	WV	194	AC	NO	GOOD	EXC.	GOOD	NO	NO	YES	NO	NO	YES	
AEA	SE	WV	174	BOTH	YES	FAIR	FAIR	GOOD	NO	NO	YES	NO	NO	NO	MAINTAINING LIGHTING
AEA	SE	WV	184	BOTH	YES	GOOD	FAIR	FAIR	NO	YES	YES	YES	NO	YES	SPALLING CONCRETE--FOD

TYPES OF PAVEMENTS AND THEIR CONDITIONS
INCLUDES: SURFACE RATINGS, FREEZE/THAW PROBLEMS,
AND PROBLEMS DURING WET SEASONS.

FAA REG	AAAE REG	ST CODE	C. TYPE PAVT	D. NEW CON	E.1 RUN COND	E.2 TAXI COND	E.3 PARK COND	F.1 THAW WATER	F.2 RAIN WATER	G.1 THAW DEB	G.2 RAIN DEB	H. ROUGH COND	I. REFLECTION CRACKING	J. GENERAL PROBLEMS ENCOUNTERED
AGL	NC	IL 099	AC	YES	EXC.	GOOD	GOOD	YES	YES	NO	NO	NO	NO	
AGL	NC	IL 092	AC	YES	FAIR	GOOD	EXC.	YES	YES	YES	YES	YES	YES	CRACKS
AGL	NC	IL 089	AC	YES	GOOD	EXC.	FAIR	YES	NO	YES	NO	NO	NO	DRAINAGE AFTER MELTING SNOW-BANK REMOVAL
AGL	NC	IL 140	AC	YES	GOOD	GOOD	FAIR	NO	NO	YES	NO	NO	NO OVERLAY	
AGL	NC	IL 150	AC	YES	GOOD	GOOD	GOOD	NO	NO	YES	YES	NO	YES	DEBRIS REMOVAL
AGL	NC	IL 109	AC	YES	POOR	FAIR	FAIR	YES	YES	YES	YES	YES	YES	SPALLING
AGL	NC	IL 029	BOTH	YES	EX/G	EX/F	EXC.	NO	NO	NO	NO	NO	CAN'T DET.	
AGL	NC	IL 062	BOTH	YES	EXC.	EXC.	POOR	YES	YES	NO	NO	NO	YES	MAINTAINING LIGHTING
AGL	NC	IL 158	BOTH	YES	EXC.	EXC.	EXC.	NO	YES	NO	NO	NO	YES	
AGL	NC	IL 076	BOTH	YES	GOOD	GOOD	GOOD	YES	YES	YES	YES	YES	YES	
AGL	NC	IL 090	BOTH	YES	GOOD	GOOD	GOOD	NO	NO	NO	NO	NO	YES	SAND REMOVAL AFTER ICING
AGL	NC	IL 131	BOTH	YES	GOOD	EXC.	GOOD	YES	NO	YES	NO	YES	YES	DRIFTING SNOW
AGL	NC	IN 019	AC	YES	FAIR	GOOD	GOOD	NO	NO	NO	YES	YES	YES	CRACKS 2-3" WIDE
AGL	NC	IN 044	AC	YES	GOOD	GOOD	GOOD	NO	NO	YES	YES	YES	NO	CRACKS WIDENING,NEW ONES VERT. PAV. SEPARATION
AGL	NC	IN 125	AC	YES	GOOD	FAIR	FAIR	NO	YES	YES	YES	NO	YES	CRACKING DUE TO F/T CYCLE
AGL	NC	IN 135	BOTH	YES	FAIR	GOOD	FAIR	YES	YES	YES	YES	NO	YES	CRACK SEALING
AGL	NC	IN 146	BOTH	YES	G/F	GOOD	F/P	YES	YES	YES	YES	YES	YES	DEBRIS FROM F/T CYCLES
AGL	NC	IN 028	BOTH	YES	GOOD	GOOD	GOOD	YES	NO	YES	NO	YES	YES	HEAVING CRACKS
AGL	NC	IN 045	BOTH	YES	GOOD	GOOD	FAIR	NO	NO	YES	NO	NO	YES	MAINTAINING LIGHTING
AGL	NC	MI 006	AC	YES	EXC.	GOOD	FAIR	NO	NO	NO	NO	YES	NO	
AGL	NC	MI 017	AC	NO	EXC.	EXC.	EXC.	NO	NO	NO	NO	NO	YES	
AGL	NC	MI 021	AC	NO	EXC.	GOOD	GOOD	NO	NO	NO	NO	NO	NO	MAINTAINING LIGHTING
AGL	NC	MI 088	AC	YES	EXC.	GOOD	G/F	NO	NO	YES	YES	NO	YES	MAINTAINING LIGHTING
AGL	NC	MI 034	AC	YES	FAIR	FAIR	GOOD	NO	NO	NO	NO	NO	YES	MAINTAINING LIGHTING

TYPES OF PAVEMENTS AND THEIR CONDITIONS
INCLUDES: SURFACE RATINGS, FREEZE/THAW PROBLEMS,
AND PROBLEMS DURING WET SEASONS.

FAA REG	AAAE REG	ST	CODE	C. TYPE PAVT	D. NEW CON	E.1 RUN COND	E.2 TAXI COND	E.3 PARK COND	F.1 THAW WATER	F.2 RAIN WATER	G.1 THAW DEB	G.2 RAIN DEB	H. ROUGH COND	I. REFLECTION CRACKING	J. GENERAL PROBLEMS ENCOUNTERED
AGL	NC	MI	040	AC	YES	FAIR	FAIR	FAIR	YES	YES	NO	NO	NO	YES	SOFT COND. SAFETY AREAS CRACKS
AGL	NC	MI	164	AC	NO	FAIR	FAIR	FAIR	YES	NO	YES	YES	YES	YES	SANDING THE RUNWAY
AGL	NC	MI	175	AC	YES	FAIR	FAIR	FAIR	YES	YES	YES	YES	YES	NO OVERLAY	SAND SPREADING, REMOVAL
AGL	NC	MI	005	AC	YES	GOOD	GOOD	GOOD	YES	YES	NO	NO	NO	NO OVERLAY	
AGL	NC	MI	075	AC	YES	GOOD	FAIR	FAIR	YES	?	YES	?	NO	YES	MAINTAINING LIGHTING
AGL	NC	MI	162	AC	YES	GOOD	GOOD	FAIR	YES	NO	NO	NO	NO	YES	
AGL	NC	MI	182	AC	NO	GOOD	GOOD	GOOD	NO	NO	NO	NO	NO	NO OVERLAY	
AGL	NC	MI	050	BOTH	YES	EX/G	EX/G	EX/G	YES	YES	NO	NO	NO	YES	SNOW REMOVAL AROUND LIGHT
AGL	NC	MI	002	BOTH	YES	F/P	GOOD	EX/G	NO	NO	YES	YES	YES	YES	BIRD BATHS IN SOME SPOTS
AGL	NC	MI	108	BOTH	YES	GOOD	GOOD	GOOD	NO	NO	YES	NO	YES	YES	REMOVAL OF SNOW-BANKS
AGL	NC	MI	043	PCC	YES	GOOD	GOOD	GOOD	YES	NO	YES	NO	NO	YES	MAINTAINING LIGHTING
AGL	NC	MI	101	PCC	YES	GOOD	GOOD	GOOD	NO	NO	NO	NO	NO	NO	
AGL	NC	MN	077	BOTH	YES	GOOD	GOOD	FAIR	YES	NO	YES	YES	YES	YES	
AGL	NC	MN	149	BOTH	YES	GOOD	GOOD	GOOD	YES	YES	YES	YES	YES	YES	SPALLING CONCRETE BITUMINOUS DETERIORATION
AGL	NC	ND	046	AC	NO	EXC.	EX/G	GOOD	YES	NO	YES	NO	NO	YES	MAINTAINING LIGHTING
AGL	NC	ND	079	AC	YES	GOOD	GOOD	FAIR	NO	NO	NO	NO	NO	NO OVERLAY	
AGL	NC	ND	128	AC	NO	GOOD	GOOD	GOOD	NO	NO	NO	NO	NO	YES	SNOW DRIFTING * SEE ATTACHED NOTES *
AGL	NC	ND	020	BOTH	NO	EXC.	EXC.	EXC.	NO	NO	NO	NO	NO	YES	SANDING
AGL	NC	ND	117	BOTH	YES	GOOD	GOOD	GOOD	YES	NO	NO	NO	NO	YES	SAND
AGL	NC	ND	081	PCC	YES	EXC.	EXC.	EXC.	NO	NO	NO	NO	NO	YES	
AGL	NC	OH	122	AC	YES	EXC.	GOOD	GOOD	NO	NO	NO	NO	NO	NO	
AGL	NC	OH	143	AC	YES	EXC.	EXC.	FAIR	YES	YES	YES	YES	YES	YES	
AGL	NC	OH	202	AC	YES	EXC.	GOOD	GOOD		NO	YES	YES	NO	NO	CRACKS OPENING
AGL	NC	OH	163	AC	YES	GOOD	GOOD	GOOD	YES	YES	YES	NO	NO	NO	SNOW REMOVAL AROUND LIGHT

TYPES OF PAVEMENTS AND THEIR CONDITIONS
INCLUDES: SURFACE RATINGS, FREEZE/THAW PROBLEMS,
AND PROBLEMS DURING WET SEASONS.

FAA REG	AAAE REG	ST	CODE	C. TYPE PAVT	D. NEW CON	E.1 RUN COND	E.2 TAXI COND	E.3 PARK COND	F.1 THAW WATER	F.2 RAIN WATER	G.1 THAW DEB	G.2 RAIN DEB	H. ROUGH COND	I. REFLECTION CRACKING	J. GENERAL PROBLEMS ENCOUNTERED	
AGL	NC	OH	023	BOTH	YES	EXC.	GOOD	FAIR	YES	YES	YES	YES	YES	YES	SPALLING	DEBRIS CAUSED BY F/T
AGL	NC	OH	061	BOTH	YES	EXC.	GOOD	GOOD	NO	YES	NO	YES	NO	YES	MAINTAINING LIGHTING	
AGL	NC	OH	106	BOTH	YES	GOOD	GOOD	FAIR	YES	YES	NO	NO	YES	YES	DEBRIS CAUSED BY F/T CYC.	
AGL	NC	OH	153	BOTH	YES	GOOD	GOOD	FAIR	NO	NO	YES	YES	YES	YES	SPALLING	
AGL	NC	OH	159	BOTH	YES	GOOD	GOOD	FAIR	NO	YES	NO	NO	NO	NO OVERLAY	SAND REMOVAL	
AGL	NC	OH	124	PCC	YES	EXC.	EXC.	GOOD	NO	NO	YES	NO	NO	NO OVERLAY		
AGL	NC	OH	155	PCC	YES	GOOD	GOOD	GOOD	YES	YES	YES	YES	YES	YES	CRACKS WITHIN 8 MONTHS	
AGL	NC	SD	007	BOTH	NO	EXC.	EXC.	EXC.	NO	NO	YES	YES	NO	YES	CRACKS SEALED WINTER	
AGL	NC	SD	054	BOTH	NO	EXC.	EXC.	GOOD	YES	NO	NO	NO	NO	YES		
AGL	NC	SD	068	BOTH	YES	EXC.	EXC.	EXC.	NO	NO	NO	NO	NO	YES	DEBRIS REMOVAL	
AGL	NC	WI	123	AC	YES	FAIR	FAIR	FAIR	YES	YES	YES	YES	YES	YES	BUMPY	
AGL	NC	WI	016	AC	NO	GOOD	GOOD	FAIR	NO	NO	NO	NO	NO	YES	DEBRIS ON C/L JOINT	
AGL	NC	WI	041	BOTH	YES	GOOD	GOOD	FAIR	YES	YES	YES	NO	NO	NO		
AGL	NC	WI	096	BOTH	YES	GOOD	GOOD	GOOD	NO	NO	YES	YES	NO	YES		
AGL	NC	WI	137	BOTH	YES	GOOD	FAIR	GOOD	NO	NO	YES	NO	NO	NO OVERLAY	REMOVING SAND	
AGL	NC	WI	051	PCC	YES	EXC.	EXC.	FAIR	NO	NO	YES	NO	YES	YES	SPALLING	DEBRIS
AGL	NC	WI	001	PCC	YES	FAIR	FAIR	FAIR	YES	NO	YES	NO	YES	YES	MAINTAINING LIGHTING	PATCHING PAVEMENT
AGL	NC	WI	010	PCC	YES	FAIR	GOOD	GOOD	YES	YES	YES	YES	YES	NO OVERLAY	HEAVING C/L AND JOINTS	
ANE	NE	CT	056	AC	YES	GOOD	FAIR	EXC.	NO	NO	YES	NO	YES	NO	VISIBILITY OF MARKINGS	
ANE	NE	CT	179	BOTH	YES	G/F	G/F	G/F	YES	YES	YES	YES	YES	YES	HEAVING AT TAXIWAY AND RW	
ANE	NE	CT	003	BOTH	NO	GOOD	G/P	EXC.	NO	YES	NO	NO	NO	NO OVERLAY		
ANE	NE	MA	036	AC	NO	EXC.	FAIR	FAIR	NO	NO	NO	NO	NO	NO		
ANE	NE	MA	091	AC	YES	FAIR	FAIR	FAIR	YES	YES	YES	YES	YES	YES	**SEE NOTES ATTACHED**	
ANE	NE	MA	078	AC	YES	G/P	GOOD	GOOD	YES	YES	NO	NO	NO	NO OVERLAY	MAINTAINING LIGHTING	

TYPES OF PAVEMENTS AND THEIR CONDITIONS
INCLUDES: SURFACE RATINGS, FREEZE/THAW PROBLEMS,
AND PROBLEMS DURING WET SEASONS.

FAA REG	AAAE REG	ST	CODE	C. TYPE PAVT	D. NEW CON	E.1 RUN COND	E.2 TAXI COND	E.3 PARK COND	F.1 THAW WATER	F.2 RAIN WATER	G.1 THAW DEB	G.2 RAIN DEB	H. ROUGH COND	I. REFLECTION CRACKING	J. GENERAL PROBLEMS ENCOUNTERED
ANE	NE	MA	008	AC	YES	GOOD	GOOD	GOOD	YES	NO	NO	NO	YES	YES	HEAVING OF ELEC. DUCTS
ANE	NE	MA	161	BOTH	YES	EXC.	EXC.	EXC.	NO	NO	YES		NO	NO	
ANE	NE	MA	152	BOTH	NO	GOOD	GOOD	GOOD	YES	NO	NO	NO	NO	NO	
ANE	NE	ME	156	AC	YES	EX/F	FAIR	POOR	YES	NO	YES	YES	YES	NO OVERLAY	CRACKING AND DEPRESSIONS
ANE	NE	ME	203	AC	NO	EX/F	GOOD	G/F	YES	YES	NO	NO	NO	NO OVERLAY	
ANE	NE	ME	048	AC	YES	POOR	POOR	POOR	NO	NO	YES	YES	NO	NO OVERLAY	DEBRIS CLEAN UP
ANE	NE	NH	138	AC	YES	FAIR	GOOD	FAIR	YES	?	YES	YES	YES	NO OVERLAY	REMOVING SAND MAINTAINING LIGHTING
ANE	NE	NH	097	AC	YES	GOOD	GOOD	FAIR	YES	?	YES	YES	NO	YES	KEEPING CATCHBASINS CLEAR
ANE	NE	RI	107	BOTH	YES	GOOD	GOOD	GOOD	NO	NO	NO	NO	NO	YES	REMOVAL OF SAND MAINTAINING LIGHTING
ANE	NE	VT	114	AC	YES	G/P	GOOD	GOOD	YES	YES	YES	YES	NO	NO	SMOOTH SURFACE
ANM	NW	CO	120	AC	YES	EXC.	EXC.	EX/P	NO	NO	NO	NO	NO	NO	MAINTAINING LIGHTING
ANM	NW	CO	166	AC	YES	EXC.	EXC.	EXC.	YES	YES	NO	NO	NO	YES	
ANM	NW	CO	188	AC	YES	EXC.	GOOD	F/P			NO		NO	NO OVERLAY	MAINTAINING LIGHTING SNOW STORAGE
ANM	NW	CO	116	AC	YES	FAIR	GOOD	FAIR	YES	NO	YES	NO	YES	YES	DEBRIS AT CRACKS & JOINTS
ANM	NW	CO	024	AC	YES	GOOD	EXC.	FAIR	YES	YES	YES	YES	NO	NO OVERLAY	MAINTAINING SAFETY AREAS AND LIGHTS.
ANM	NW	CO	049	AC	YES	GOOD	FAIR	FAIR	YES	YES	NO	NO	NO	YES	
ANM	NW	CO	053	AC	NO	GOOD	GOOD	FAIR	NO	NO	YES	NO	NO	YES	RUNOFF
ANM	NW	CO	095	AC	YES	GOOD	GOOD	FAIR	YES	YES	NO	NO	NO	NO	SNOW REMOVAL
ANM	NW	CO	169	AC	YES	GOOD	GOOD	FAIR	YES	NO	NO	NO	YES	NO OVERLAY	REMOVAL OF SNOW AND SLUSH
ANM	NW	CO	193	AC	NO	GOOD	GOOD	GOOD	NO	YES	NO	NO	NO	YES	
ANM	NW	CO	201	PCC	YES	EX/G	EX/G	FAIR	NO	YES	YES	NO	YES	YES	SPALL REPAIR AT JOINTS
ANM	NW	ID	038	AC	YES	EX/P	GOOD	GOOD	NO	NO	NO	NO	YES	YES	DEBRIS-10+ YEAR OLD FRICT COARSE BREAKING UP
ANM	NW	ID	057	AC	YES	FAIR	GOOD	GOOD	NO	NO	YES	YES	YES	NO OVERLAY	CRACKS WIDENING
ANM	NW	ID	037	AC	YES	GOOD	GOOD	GOOD	NO	NO	NO	NO	NO	NO	

TYPES OF PAVEMENTS AND THEIR CONDITIONS
INCLUDES: SURFACE RATINGS, FREEZE/THAW PROBLEMS,
AND PROBLEMS DURING WET SEASONS.

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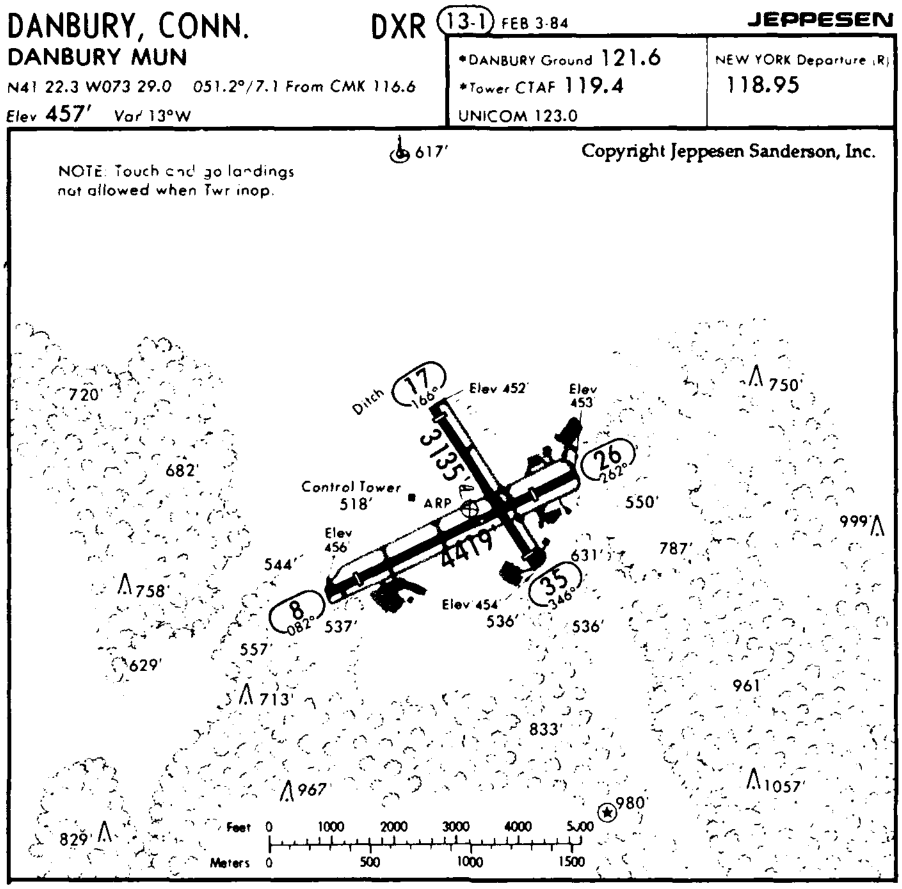
ANM	NW	MT	039	AC	YES	EXC.	EXC.	GOOD	NO	NO	NO	NO	NO	YES	
ANM	NW	MT	067	AC	NO	EXC.	EXC.	GOOD	NO	NO	NO	NO	YES	YES	ICE PATCHES (SEE NOTES)
ANM	NW	MT	121	AC	YES	FAIR	GOOD	GOOD	YES	NO	YES	YES	YES	YES	HEAVING CRACKING
ANM	NW	MT	033	AC	YES	GOOD	GOOD	GOOD	NO	NO	NO	NO	NO	YES	
ANM	NW	MT	070	AC	YES	GOOD	EXC.	EXC.	NO	NO	NO	NO	NO	YES	
ANM	NW	MT	144	AC	YES	GOOD	GOOD	EXC.	NO	NO	NO	NO	NO	YES	
ANM	NW	MT	139	BOTH	YES	EXC.	GOOD	GOOD	YES	YES	YES	YES	YES	YES	FREEZE THAW CYCLE
ANM	NW	MT	098	NONE	YES	GOOD		GOOD	NO	NO	NO	NO	NO	NO OVERLAY	
ANM	NW	OR	181	AC	NO	EXC.	EXC.	EXC.	NO	NO	NO	NO	NO	NO	MINOR SHOULDER EROSION
ANM	NW	OR	183	AC	YES	EXC.	EXC.	G/P	NO	NO	NO	NO	NO	NO	MAINTAINING LIGHTING-SNOW REMOVAL
ANM	NW	OR	191	AC	YES	EXC.	G/F	GOOD	NO	NO	NO	NO	NO	NO	
ANM	NW	OR	197	AC	YES	EXC.	EXC.	GOOD	NO	NO	NO	NO	NO	YES	
ANM	NW	OR	177	AC	YES	GOOD	EXC.	GOOD	NO	NO	NO	NO	NO	NO	
ANM	SW	UT	204	AC	NO	EX/P	GOOD	GOOD	YES	NO	NO	NO	NO	NO OVERLAY	
ANM	SW	UT	198	AC	NO	EXC.	EXC.	EXC.	YES	YES	YES	NO	YES	NO OVERLAY	
ANM	SW	UT	180	BOTH	YES	GOOD	GOOD	GOOD	YES	NO	NO	NO	NO	NO	F-O-D PROBLEMS
ANM	NW	WA	025	AC	YES	EX/G	EXC.	EXC.	NO	NO	NO	NO	NO	NO	
ANM	NW	WA	085	AC	YES	G/F	GOOD	GOOD	YES	NO	YES	NO	YES	YES	POOR TRACTION
ANM	NW	WA	072	AC	YES	GOOD	GOOD	GOOD	NO	NO	YES	NO	YES	YES	FROST HEAVING AND CRACKS
ANM	NW	WA	102	AC	YES	GOOD	EXC.	GOOD	NO	NO	NO	NO	NO	YES	SAND ACCUMULATION ON PFC
ANM	NW	WA	030	BOTH	NO	EXC.	EXC.	GOOD	NO	NO	NO	NO	NO	YES	EDGE LIGHTS CLEAR OF SNOW
ANM	NW	WA	035	BOTH	NO	EXC.	GOOD	GOOD	YES	NO	NO	NO	NO	YES	ADEQUATE DRAINAGE
ANM	NW	WA	074	BOTH	YES	GOOD	GOOD	GOOD	NO	NO	YES	?	NO	NO	SPALLING @ JOINTS DEBRIS
ANM	NW	WA	086	BOTH	YES	GOOD	GOOD	G/P	YES	YES	YES	YES	NO	NO	DEBRIS FROM CRACKS/SPALLS

TYPES OF PAVEMENTS AND THEIR CONDITIONS
INCLUDES: SURFACE RATINGS, FREEZE/THAW PROBLEMS,
AND PROBLEMS DURING WET SEASONS.

FAA REG	AAAE REG	ST	CODE	C. TYPE PAVT	D. NEW CON	E.1 RUN COND	E.2 TAXI COND	E.3 PARK COND	F.1 THAW WATER	F.2 RAIN WATER	G.1 THAW DEB	G.2 RAIN DEB	H. ROUGH COND	I. REFLECTION CRACKING	J. GENERAL PROBLEMS ENCOUNTERED
ANM	NW	WA	094	BOTH	YES	GOOD	FAIR	FAIR	YES	NO	YES	NO	YES	YES	MAINTAINING LIGHTING
ANM	NW	WY	012	AC	YES	GOOD	GOOD	FAIR	NO	NO	NO	NO	YES	NO OVERLAY	
ANM	NW	WY	093	AC	YES	GOOD	EXC.	FAIR	YES	?	YES	?	YES	YES	HEAVING DURING FREEZES
ANM	NW	WY	113	AC	YES	GOOD	GOOD	FAIR	YES	YES	YES	YES	YES	NO	SNOW REMOVAL AROUND LIGHT
ANM	NW	WY	052	PCC	YES	EX/P	GOOD	EXC.	YES	NO	YES	YES	NO	YES	SPALLING OF PCC @ CORNERS
ASO	SE	KY	176	BOTH	YES	EXC.	EXC.	GOOD	YES	YES	YES	YES	NO	YES	MAINTAINING LIGHTING
ASO	SE	KY	187	BOTH	NO	EXC.	EXC.	EXC.	YES	YES	YES	YES	NO	NO OVERLAY	DRAINAGE FROM PAVED SURF.
AWP	SW	AZ	178	AC	YES	EXC.	EXC.	POOR	YES	YES	NO	NO	NO	NO OVERLAY	MAINTAINING LIGHTING
AWP	SW	AZ	205	AC	YES	EXC.	EXC.	EXC.	NO	NO	NO	NO	NO	NO OVERLAY	
AWP	SW	AZ	196	AC	YES	GOOD	EXC.	GOOD	NO	NO	NO	NO	YES	YES	
AWP	SW	CA	195	AC	YES	EX/P	EX/P	EXC.	N/A	YES	N/A	YES	NO	NO	
AWP	SW	CA	190	AC	YES	EXC.	EXC.	FAIR	NO	YES	NO	YES	NO	YES	FOG
AWP	SW	CA	189	AC	NO	GOOD	GOOD	FAIR	NO	NO	NO	NO	NO	YES	
AWP	SW	CA	200	BOTH	NO	EXC.	EXC.	G/F	NO	NO	NO	NO	NO	NO	FOG AND RAIN

APPENDIX C: NARRATIVE SUMMARY OF SITE VISITS.

(Note: Airport diagrams are reproduced with permission of Jeppesen Sanderson, Inc.)



<u>Site Visitation Group</u> Visitation Date: 29 July 1985

T.S. Vinson, USACRREL; P. Estefan, Danbury Airport Administration.

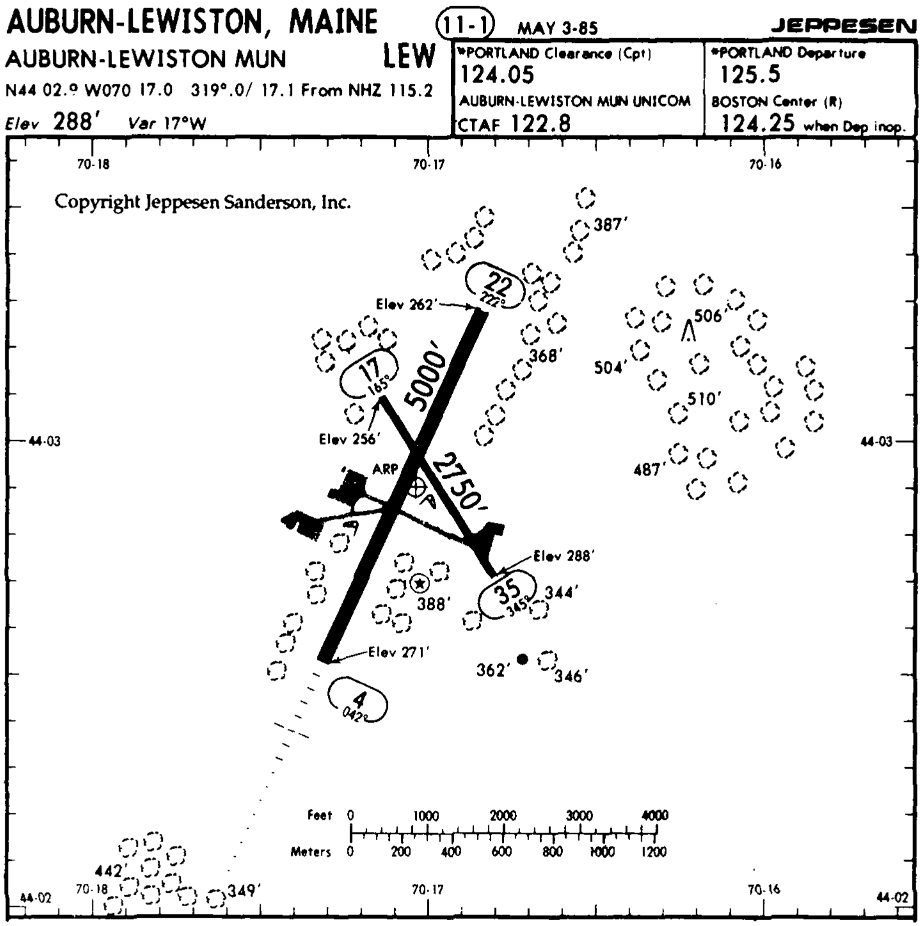
<u>Description of Airport</u> FAA Region: ANE AAAE Region: NE

Danbury Airport was originally constructed prior to World War II. During World War II, Runway 8-26 was extended. The characteristics of the original pavement structure are not well known. Runway 8-26 was overlaid in 1972 and Runway 17-35 in 1973. The airport is situated in a natural drainage basin which results in a shallow ground water table. The taxiways are PCC and the runways are AC.

<u>Discussion of Problems</u>

Severe differential frost heave (~4 in) has occurred in Taxiway A parallel to Runway 26. The problem was corrected immediately following its occurrence with an AC transition zone. The slab differential still remains, however, and the AC transition zone is breaking apart.

Over the past two years, Estefan has spent $60,000 on crack repair at the airport. The crack sealant has seeped into the cracks and is now ineffective in preventing water infiltration in many areas. This situation arose in spite of adherence to a set of crack sealing specifications that were reviewed by local FAA engineers. The specifications reflected commonly accepted crack sealing practices.



<u>Site Visitation Group</u> Visitation Date: 16 July 1985

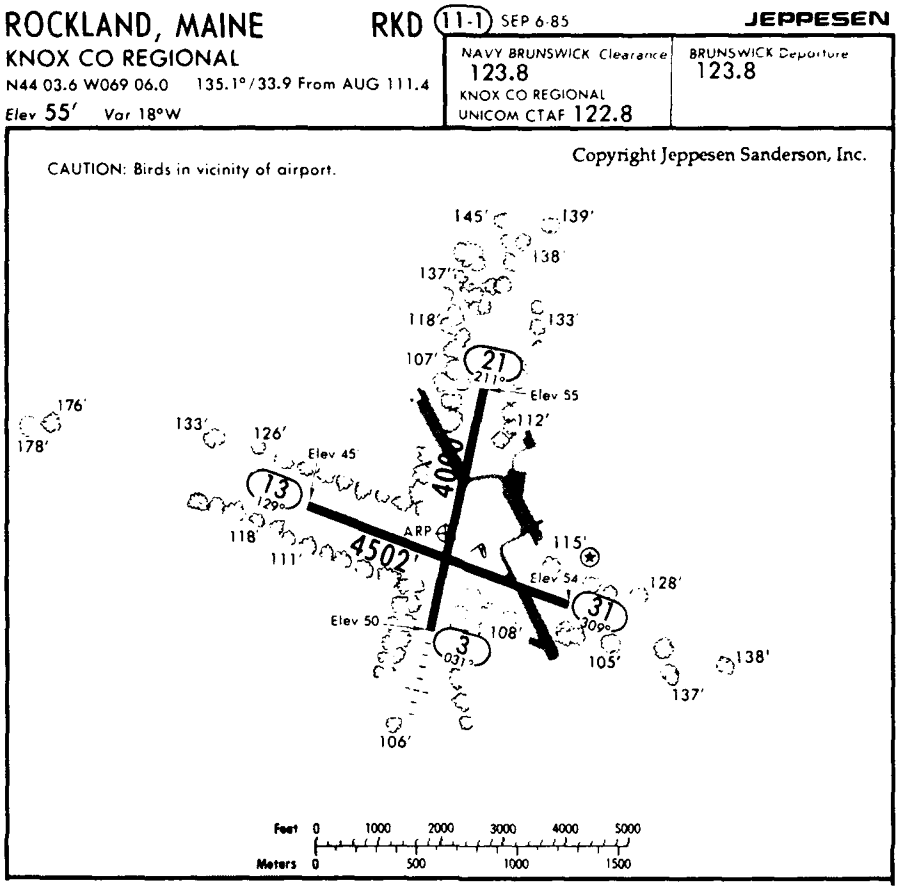
T.S. Vinson, USACRREL; J. Gongoll, Airport Manager; F. Giguere, Maintenance Supervisor.

<u>Description of Airport</u> FAA Region: ANE AAAE Region: NE

The airport was originally constructed in 1935. Substantial improvements were made through the mid-1940s. In 1960, Runway 4-22 was repaired and extended. Runway 17-35 was reconstructed in 1973. One thousand feet of the south end of Runway 4-22 was reconstructed in 1978. All pavements are AC. The structural sections for the runway, taxiway, and aprons are not known.

<u>Discussion of Problems</u>

Runway 4-22 has major transverse and longitudinal cracking and significant areas of "random" cracking. There are four distinct areas on Runway 4-22 of significant differential frost heave. They backfilled a culvert crossing the runway with the same material as underlying the runway but differential heaving across the culvert crossings still occurred.



Site Visitation Group

Visitation Date: 16 July 1985

T.S. Vinson, USACRREL; J. Danforth, Airport Manager.

Description of Airport

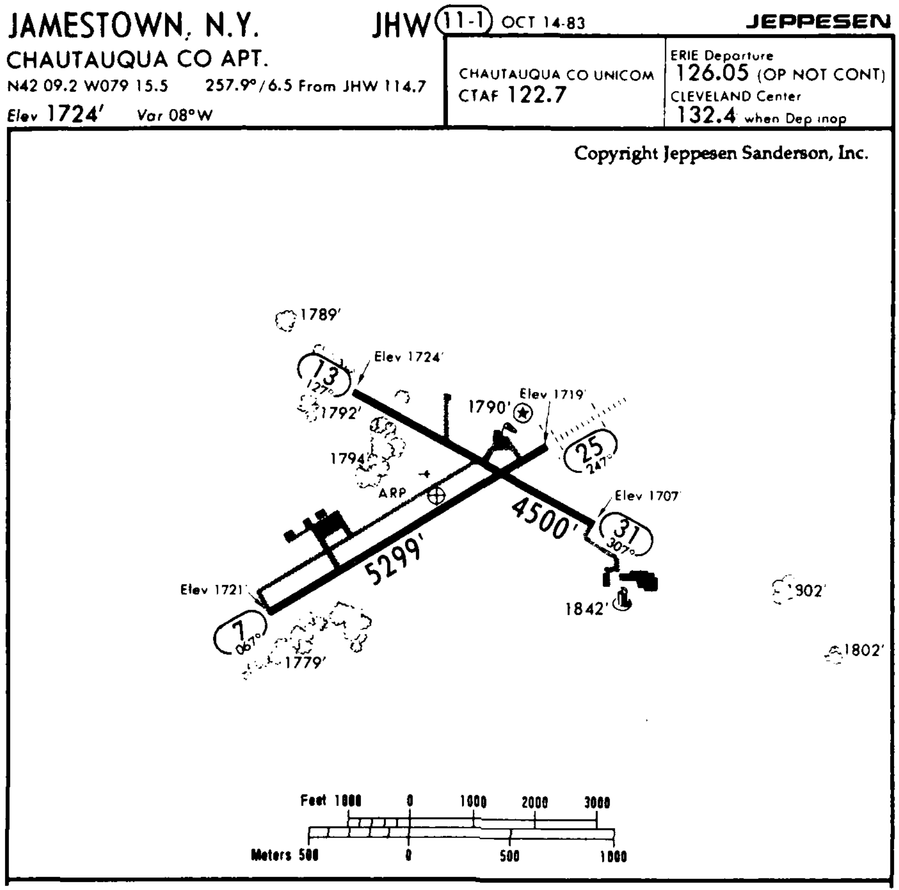
FAA Region: ANE

AAAE Region: NE

The original airport was constructed in the early 1940s. In 1974, runway 3-21 was rebuilt by grinding up the old AC, mixing it with the base, and resurfacing with AC. In 1984, Runway 13-31 was rebuilt with the same procedure. The new AC surface is approximately 3 in.

Discussion of Problems

Longitudinal construction joint cracks and transverse cracks were evident. The airport manager did not have money for crack filling in his maintenance budget. The manager advocated using "stripe" rather than solid paint for numbers and the designation of "end of runway" to minimize differential heave between painted and non-painted areas.



Site Visitation Group — Visitation Date: 2 August 1985

I. Zomerman, USACRREL; Kenneth Brentley, Chautauqua County Airport.

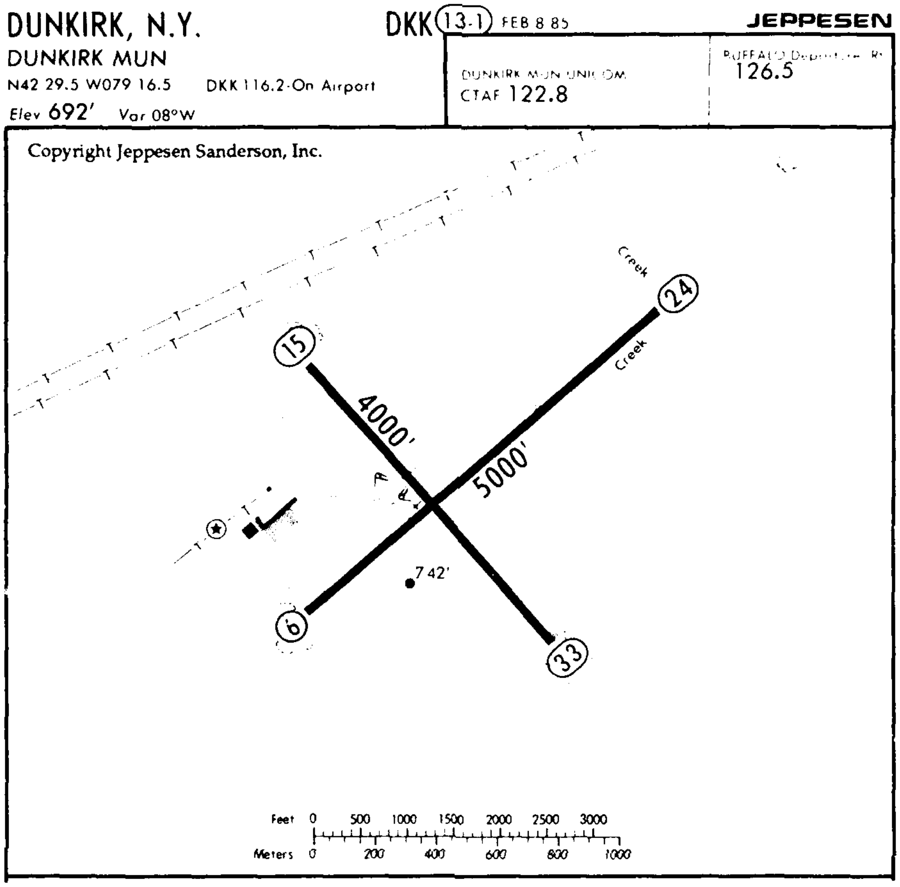
Description of Airport — FAA Region: AEA — AAAE Region: NE

Chautauqua County Airport is built on a clay mound. The water table is variable, but is approximately two feet below the pavement. Both runways were constructed with AC pavements in the early 1930s, then later overlaid.

Discussion of Problems

Severe differential heave has been experienced at several locations. Both runways have less than 16 in. of base and subbase material over a frost susceptible subgrade. Also, the high water table makes it almost impossible to get good vibratory compaction, as experienced when building the new taxiway extension.

Transverse cracks occur at regular intervals and longitudinal cracks were observed in the wheel paths as well as the paving joints. The crosswind runway edges are peeling off, and birdbaths were observed there and on the parallel taxiway. The crack sealing program is better now that a flexible filler is being used instead of a cold-mix patch fillers.



Site Visitation Group

Visitation Date: 2 August 1985

I. Zomerman, USACRREL; Hugh DeLong III, Manager, Dunkirk Municipal Airport.

Description of Airport

FAA Region: AEA

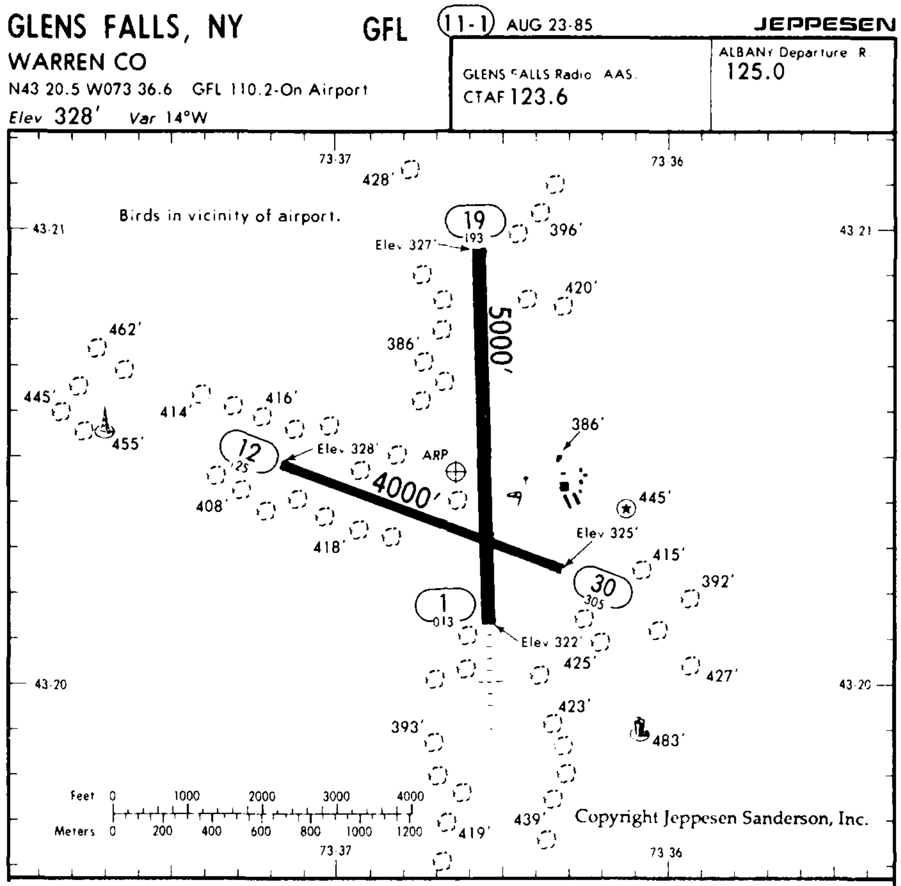
AAAE Region: NE

Dunkirk Municipal Airport was built in 1942 to help with the war effort. It was built in a lowland area with a fluctuating water table. No overlays or major repairs have been made on the airport during the last fifteen years. There are underdrains on one runway. All runways and taxiways at the airport are AC.

Discussion of Problems

The main problem at the airport is water pumping up through the cracks in the pavement. This occurs throughout the year, even when snow is being plowed. To correct the problem, it is proposed that underdrains be placed at the runway edges to remove the excess water.

There are problems with both deer and seagulls on the runways, mainly during the spring and fall. There are three proposed wildlife refuge areas in the vicinity of the take-off and landing pattern areas. If all three are approved, the airport would close down.



Site Visitation Group Visitation Date: 11 August 1985

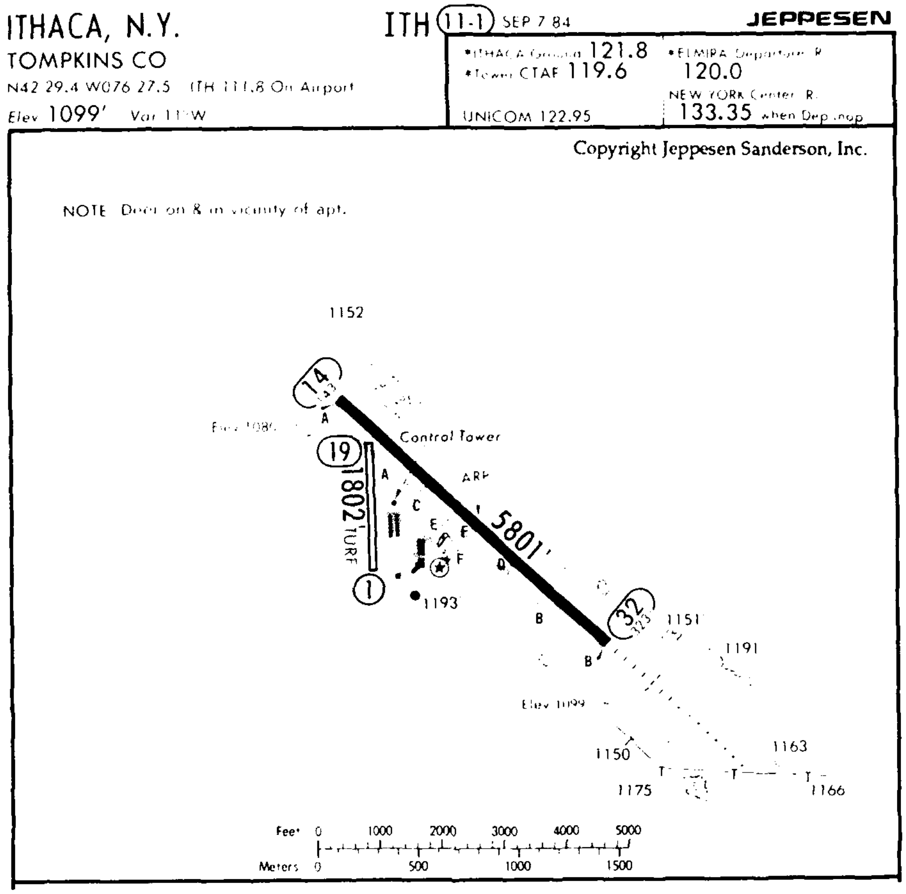
I. Zomerman, USACRREL; Fred Austin, Superintendent of Public Works-Warren County.

Description of Airport FAA Region: AEA AAAE Region: NE

Warren County Airport was built in the 1940s by the War Department. The subgrade material varies from marine clays to peat. The runway structures are composed of about 12 in. of gravel as a subbase then about 10 in. of dry bound macadam overlays of at least 3 in. These overlays have had reflective cracks appear within two years. The taxiways are also AC.

Description of Problems

There appears to be no differential heaving at the airport, but cracking and FOD generation are major problems. Pumping water up through the reflected cracks is another problem. It was noted that there is an absence of braking action standards for general aviation airports.



<u>Site Visitation Group</u> Visitation Date: 1 August 1985

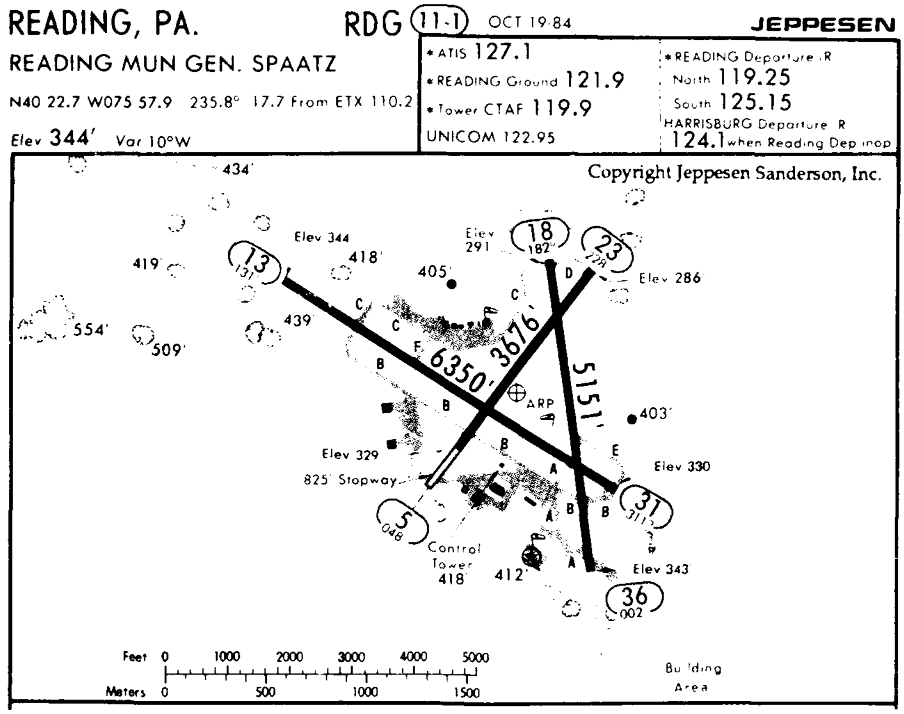
I. Zomerman, USACRREL; John J. Joubert, Tompkins County Airport.

<u>Description of Airport</u> FAA Region: AEA AAAE Region: NE

Tompkins County Airport was built in 1956. In 1959, they placed a base course over the original runway, lengthening and widening it. Again in 1967, they lengthened the runway to its 5801 ft and added a parallel taxiway. In 1978, they overlaid and grooved the runway. The runway has single slope drainage into a natural drainage basin. The crosswind runway is turf while the main runway and parallel taxiway are AC.

<u>Discussion of Problems</u>

Heave is apparently a problem in the apron area. The major cracking problems are load related. The airport runway was not designed to carry the traffic it now serves. Also, one transverse crack appears over each cross drain.



<u>Site Visitation Group</u> Visitation Date: 9 August 1985

I. Zomerman, USACRREL; John Missmer and Terry Sroke, Maintenance personnel, Reading Municipal Airport.

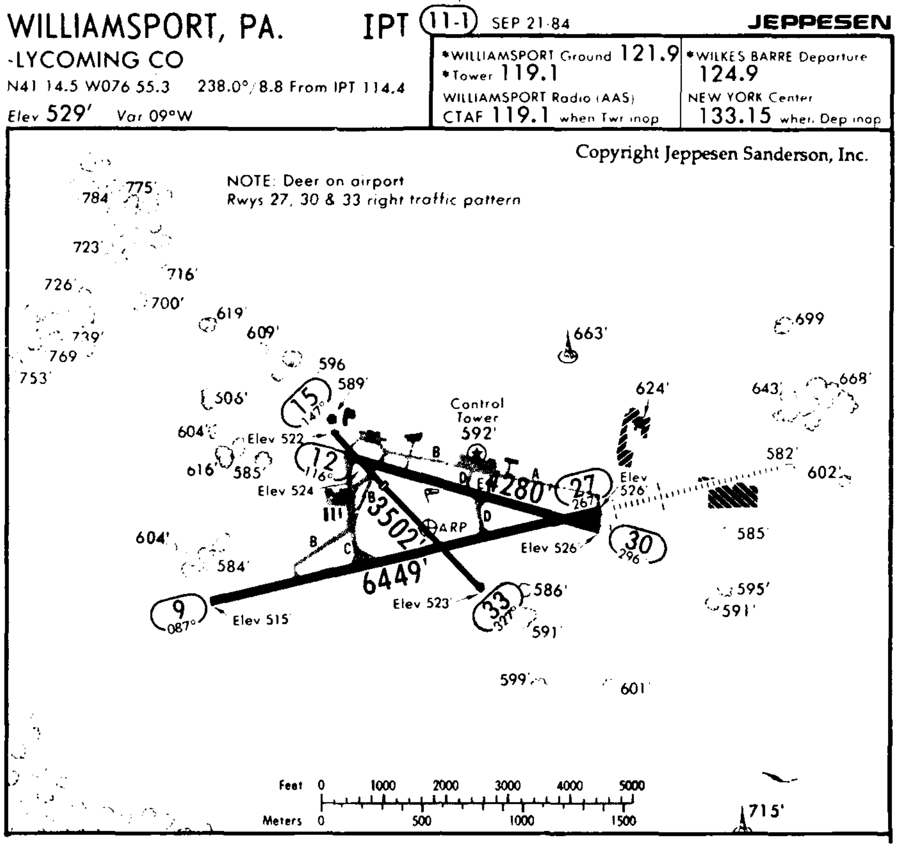
<u>Description of Airport</u> FAA Region: AEA AAAE Region: NE

The airport was built in 1936 by the Army Corps of Engineers. Of the three original runways, two were converted to taxiways and the other, 18-36, was lengthened and widened to its present state. The other two present runways are designed with 2 in. of AC over 10-12 in. of slag and shale base. Each runway has a 300 ft end of 6 in. PCC slabs instead of the 2 in. of AC and 4 in. of slag. All runways are now overlaid with AC and grooved. The original runways have underdrains on both sides if the runway is crowned or on the low sides if the runways are single sloped.

<u>Description of Problems</u>

Many of the airport problems stem from being built with a shale fill on a limestone subgrade. There are some problems with sinkholes and general breakdown of the pavement structures. The southern end of runway 5-23 has been closed due to disintegration of the pavement structure, making it unsafe for landing or takeoff. The very end of the runway required 2 in. of planing to correct slab movements and make it safe as a stopway.

The runway has several areas which have experienced heave and cracking. Most of the cracks are reflecting through the overlays.



Site Visitation Group — Visitation Date: 9 August 1985

I. Zomerman, USACRREL; Nelson Brownlee, Airport Manager.

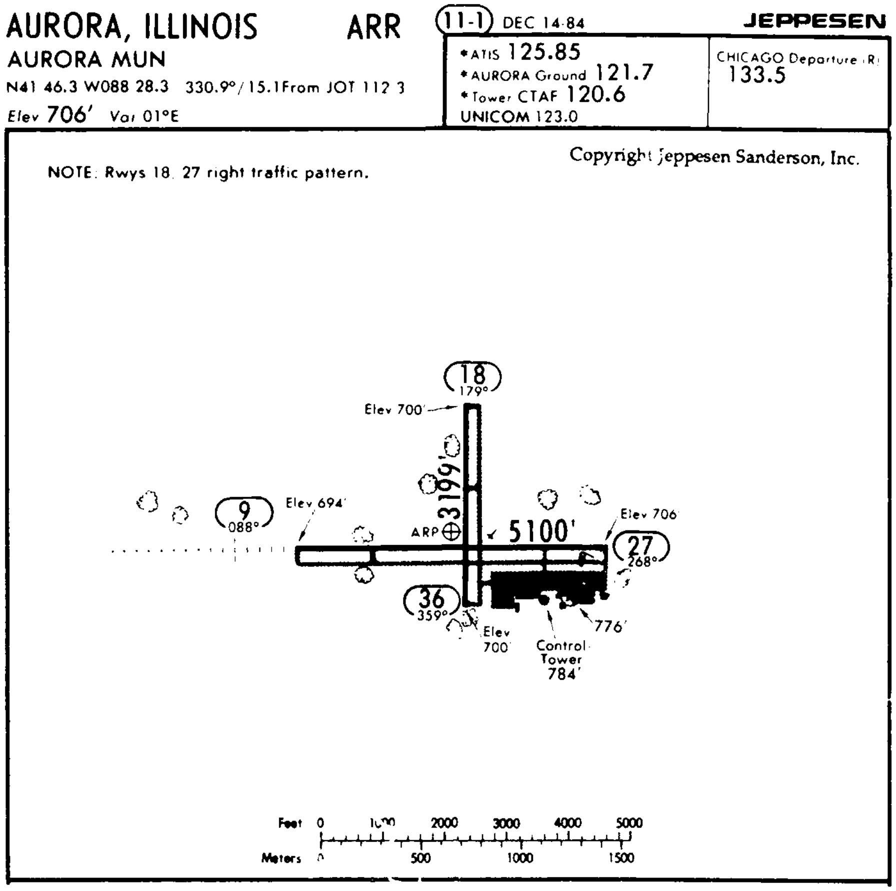
Description of Airport — FAA Region: AEA — AAAE Region: NE

The airport was originally designed and built in the late 1920s. Of the four original PCC runways, one has already been abandoned and a second runway will be shortly. The main runway 9-27 has had two AC extensions: one in 1958, the other in 1970. The main runway and first extension have been overlaid with an additional AC pavement and the entire runway was grooved in 1978.

Discussion of Problems

This airport is located in a drainage basin and major flood damage has occurred to the runways at least once. Some sections of runway 9-27 had the AC course peeled off. There is also a differential settlement problem occurring in the same area.

Drainage of the airport is accomplished by drop inlets. There are no underdrains and a few French drains but these tend to freeze up during the winter, leaving areas where water and ice remain on the runways. It was noted that there is an absence of braking action standards for general aviation airports.



<u>Site Visitation Group</u> Visitation Date: 9 September 1985

W. Haas, Mich. Tech. Univ.; R. Benko, Regional Paving Engineer, FAA, Chicago; Robert Riesner, Airport Manager.

<u>Description of Airport</u> FAA Region: AGL AAAE Region: NC

The runway pavement section consists of 14 in. of full-depth AC.

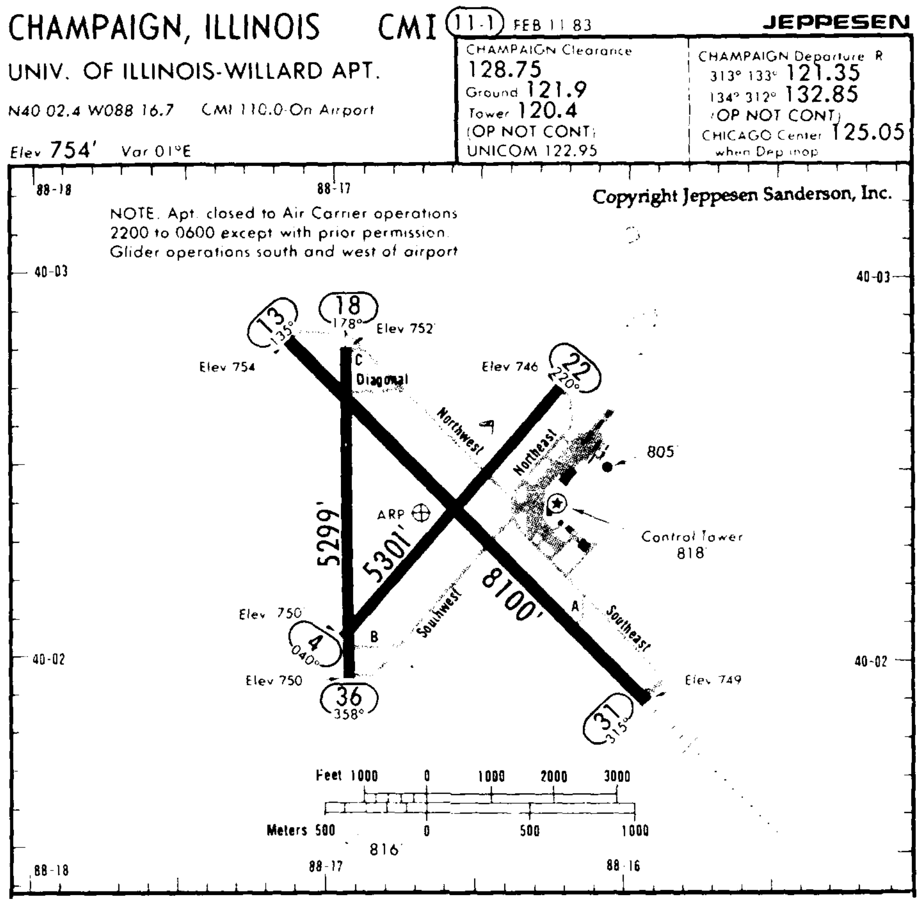
<u>Discussion of Problems</u>

Most of the problems observed were in the apron area. A deep, wide crack was observed in the apron area extending from the edge of the apron to the hangars. The crack is at least one foot deep.

Drainage is very poor and may be associated with too much reliance on french drains. Some of these were essentially nullified when they were cut through to permit the installation of electrical cables. There is evidence of heaving at drain pipes, etc., resulting in differential movement of the pavement. Water trapped beneath the pavement was bleeding out through cracks in the pavement. There was ponding of water on the pavement due to differential heaving and/or settlement. The concrete tie-down anchor blocks had heaved as much as 0.3 ft. Sawed joints were used in the asphalt pavement at a spacing of 100 ft.

The access box for the lighting system heaves in the winter and gets in the way of snow removal equipment. The filler used in the sawed joints did not appear to bond. There is some evidence of differential heaving of the joint, as indicated by snowplow marks,

Differential heaving was observed where a pavement was widened to one side only. The widened structure covered the existing edge drain so that it functioned more like a centerline drain. This is an example of some of the problems of stage construction, in this case, widening.



<u>Site Visitation Group</u> Visitation Date: 10 September 1985

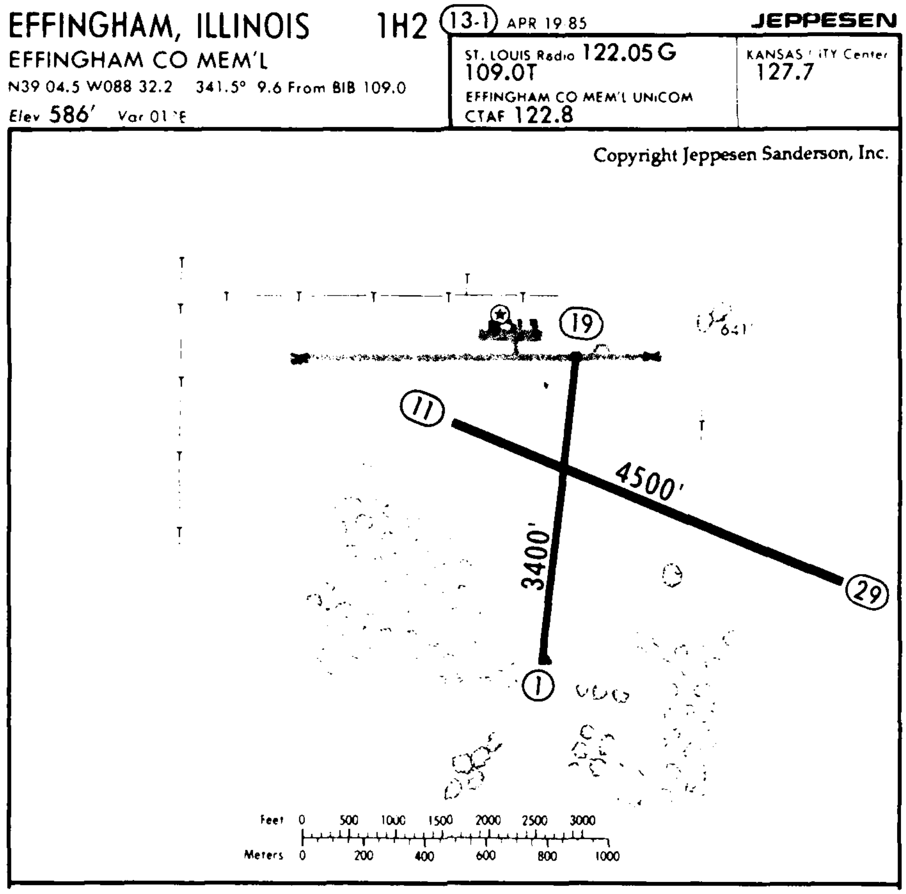
W. Haas, Mich. Tech. Univ.; R. Benko, Regional Paving Engineer, FAA; Nick Merrill, U. of Illinois; C. Burgard, Illinois DOT.

<u>Description of Airport</u> FAA Region: AGL AAAE Region: NC

The original pavement structure was constructed between 1943-45 with 9 in. of PCC. A bonded PCC overlay was constructed in 1973 and 1978 over several sections of the runway.

<u>Discussion of Problems</u>

This airport is generally in very good condition. The central portion of runway 18-36 is the original 1945 PCC pavement, and it is still in good condition. A few small areas have required repair. Runway 4-22 was resurfaced in 1978 with 7-3/4 in. fully bonded PCC overlay over the previous 11 in. PCC pavement. A few spots were noted where the crack pattern suggests localized frost heave, such as Station 54+00 on the original 1945 pavement. One possible reason for the generally good pavement performance is that the main runway was designed for Boeing 727 loading.



<u>Site Visitation Group</u> Visitation Date: 10 September 1985

W. Haas, Mich. Tech. Univ., R. Benko, Regional Paving Engineer, FAA; Leon Tate, Airport Manager; Marvin Taylor; C. Burgard, Illinois DOT.

<u>Description of Airport</u> FAA Region: AGL AAAE Region: NC

Runway 11-29 is constructed of PCC on a clay subgrade and runway 1-19 is constructed of AC.

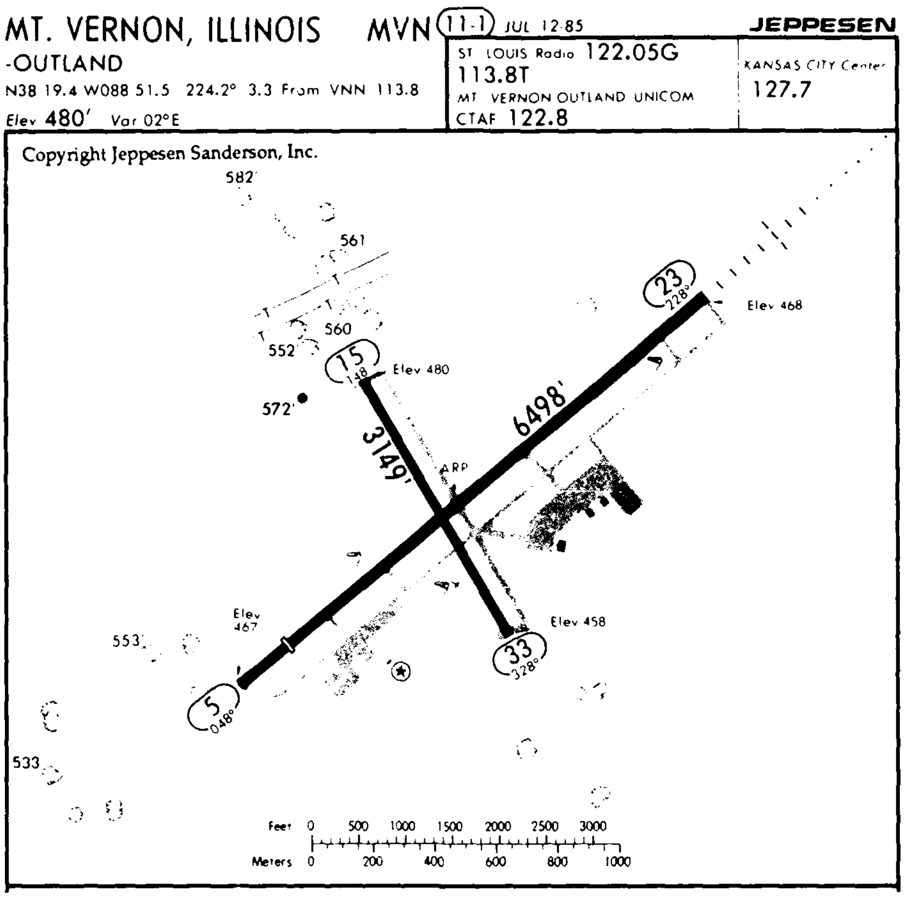
<u>Discussion of Problems</u>

The joint seal on new PCC pavement is not adhering to the concrete. In addition, there are various mid-slab cracks in the new PCC pavement as well as corner cracks.

In some places, moisture beneath the slab is apparently forcing the sealer out of the joint or crack and depositing it on the surface of the pavement. The extruded sealer is quite common on the two outside lanes on the north side of the runway. The extruded sealant is most pronounced in the outside paving lane, extends into the next lane, and becomes less noticeable in the direction of the centerline. In fact, it seems to disappear before the third paving lane is reached.

There were several instances of irregular longitudinal cracking down the approximate center of the outside paving lane. In some locations, a secondary crack branches off from the main crack, with the result that rather small blocks are being formed. This crack pattern may be due to frost action. The subgrade is clay, drainage is poor, and the cracks have formed on both sides of the runway. The longitudinal cracks have been filled with crack sealer, and show rather severe bubbling out of the sealer. Spalling of the longitudinal cracks is beginning to take place. In addition to a potential FOD problem, this will permit water to enter the main crack through the spall, thus bypassing the seal.

A photo taken during take-off from runway 11 shows approximately 200 ft of longitudinal crack down the approximate center of the outside paving lane.



Site Visitation Group | Visitation Date: 10 September 1985

W. Haas, Mich. Tech. Univ., R. Benko, Regional Paving Engineer, FAA; C. Burgard, Illinois DOT.

Description of Airport | FAA Region: AGL | AAAE Region: NC

Runways 5-23 and 15-33 have approximately 12 in. of AC. The construction history is not known. An open-graded porous friction course was added in 1982.

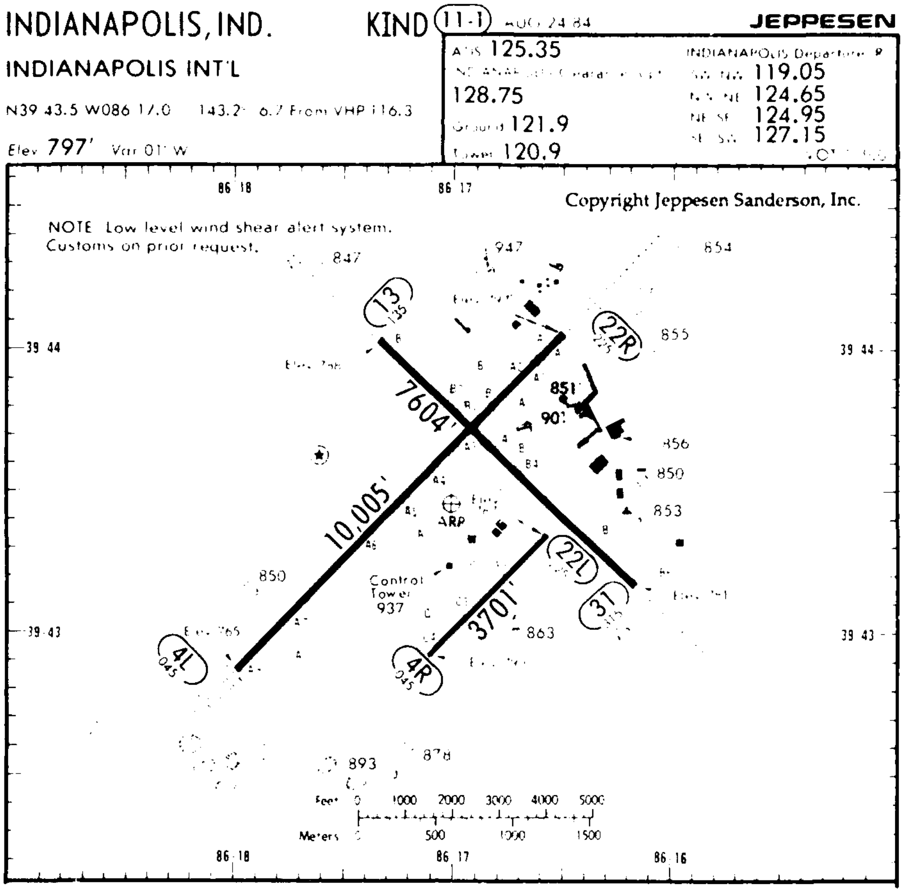
Discussion of Problems

An open-graded porous friction course was applied three years ago (1982) on runway 5-23 and generally looks quite good. There are a few places, however, where there are some transverse cracks in this overlay. They were usually only a few feet long, and may be more related to construction conditions than to cold temperature effects. These cracks seem to be concentrated in one paving lane. There were some instances of longitudinal cracks as well, and at least one longitudinal crack had been sealed. These were apparently on the joints between paving lanes. There was at least one instance of a longitudinal crack down the center of a paving lane (not on the joint), with some associated minor transverse cracking.

There was one example of a transverse crack that apparently reflected through from the original pavement. It crossed most of the runway, and was deep, as seen at the edge of the pavement. Filler is bonding well to the sides of the crack, and it is pliable to the touch at this time.

The thickness of the porous friction course is 5/8 in. and the maximum size of the limestone aggregate is 3/8 in.

Preformed neoprene seals on the PCC apron area are in very good condition.



<u>Site Visitation Group</u> Visitation Date: 11 September 1985

W. Haas, Mich. Tech. Univ.; R. Benko, Regional Paving Engineer, FAA; Jim Hall, Indianapolis International Airport.

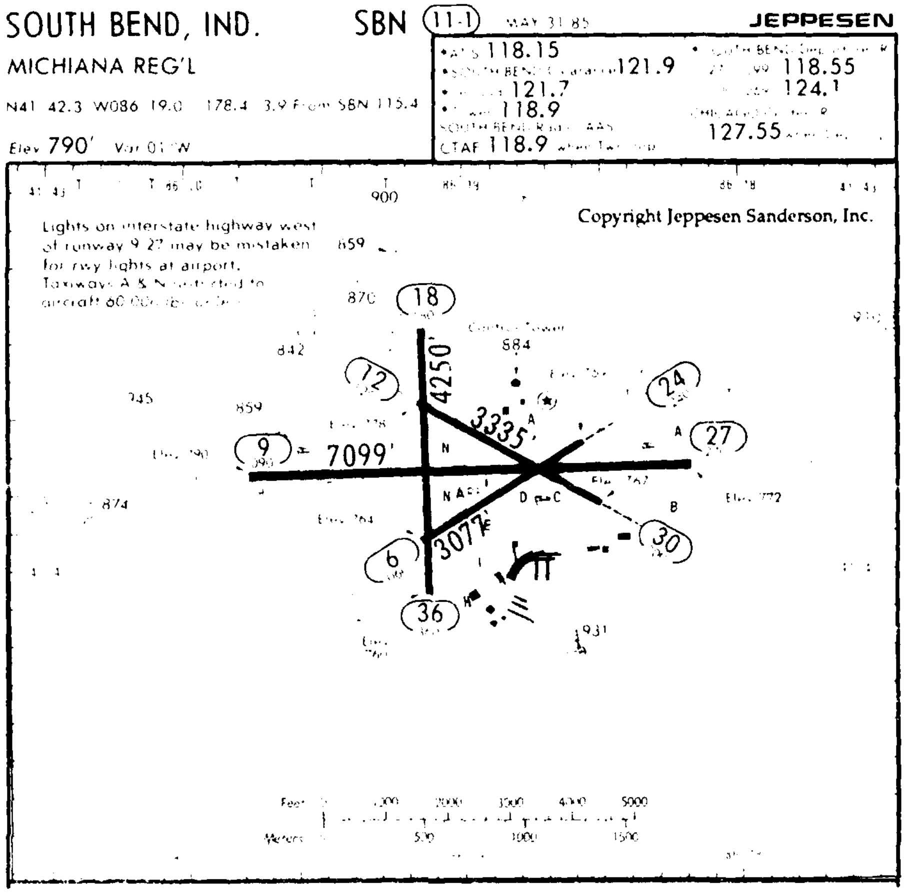
<u>Description of Airport</u> FAA Region: AGL AAAE Region: NC

This airport serves passenger carriers (about 1,000,000 persons/year), and a new large air cargo operation(Purolator). Many of these flights involve DC-10s and L1011s, with an occasional Boeing 747. Runway 13-31 was overlaid to protect the PCC surface from deterioration. The original pavement at the airport was all PCC, and current construction is with PCC.

<u>Discussion of Problems</u>

At the time of the site visit (September 1985), one catch basin was an inch or more above the slab, but in winter the slab is about 1/2 to 3/4 in. above the catch basin grate. The PCC pavement was generally in good condition. There was some spalling near the joints, and there was some corner breakage which was patched with an AC mix. The pavement distress is considered to be due to a combination of structural loading, freeze-thaw action, and pumping.

Runway 13-31 was overlaid in 1977 with an AC surface. Joints were sawn into this overlay directly over the PCC joint system of the original pavement, with the objective of minimizing reflection cracking. These sawn joints were filled with a hot-poured sealer, which generally seems to be working well. This overlay was grooved in the autumn of 1978, and is still in good condition. It should be noted that 13-31 is the cross-wind runway, so usage is not as heavy as on other runways. Some cracking is beginning to develop along the paving lane construction joints.



Site Visitation Group   Visitation Date: 11 September 1985

W. Haas, Mich. Tech. Univ.; R. Benko, Regional Paving Engineer, FAA; Tim Meek, South Bend Airport; Wayne Reynolds, Indiana State Aeronautics.

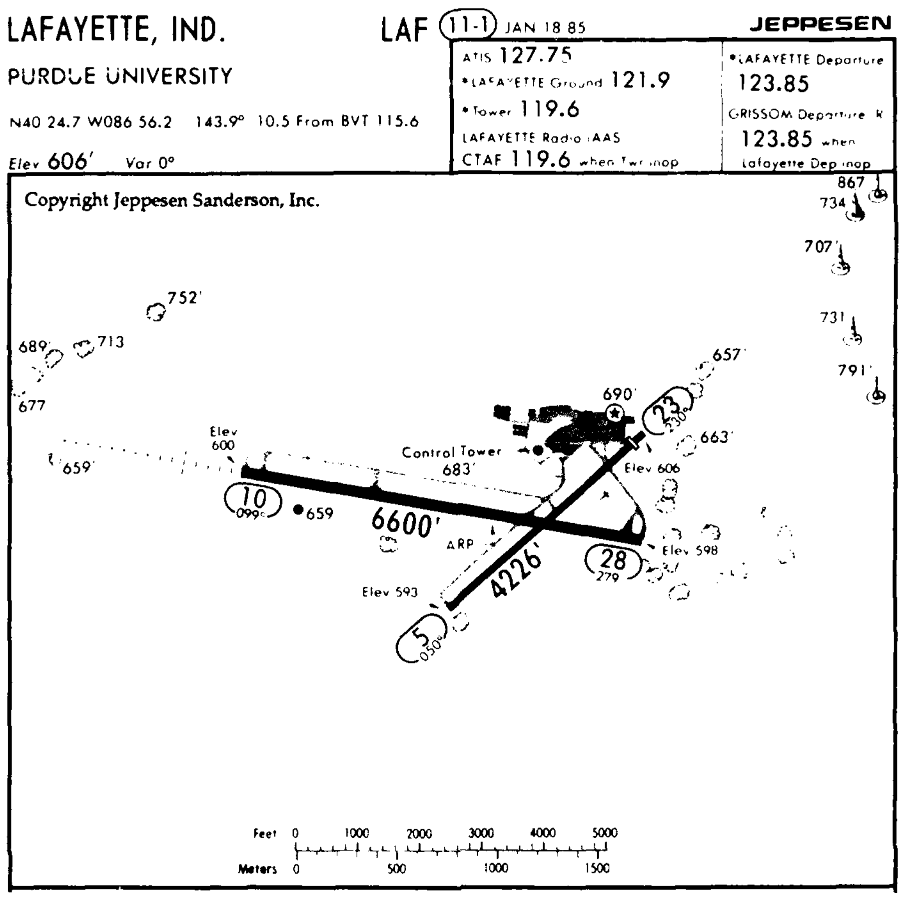
Description of Airport   FAA Region: AGL   AAAE Region: NC

South Bend has approximately 200,000 passengers per year. Boeing 727s, 737s, and DC-9s and general aviation aircraft use the runways.

Discussion of Problems

Few problems were observed at the airport. One case of shoving of the asphalt pavement was observed on the apron area. This was very prominent, and appeared much like the shoving that often occurs on a highway at a stop sign when too soft a mix is used. There did not seem to be an explanation for the shoving.

There was pronounced base course failure on one of the taxiways, with approximately parallel cracks, some less than one foot apart. These were not considered to be frost-related.



<u>Site Visitation Group</u> Visitation Date: 11 September 1985

W. Haas, Mich. Tech. Univ.; R. Benko, Regional Paving Engineer, FAA; Robert Stroud, Airport Manager; Wayne Reynolds, Indiana State Aeronautics.

<u>Description of Airport</u> FAA Region: AGL AAAE Region: NC

Because of its connection with an educational institution, this airport may have received more attention than most. The main runway has a single design throughout its length, but the shorter runway is experimental. The subgrade is typically about two feet of silty clay over sand. The estimated depth of frost penetration is three ft.

<u>Discussion of Problems</u>

There is progressive deterioration of the cracks formed in the asphalt concrete, similar to what has been observed elsewhere. Following the initial crack, another develops a few inches away and parallel to it. Subsequently, this material ravels into the deeper portion of the crack.

Transverse crack repair was done by sawing out about one ft on either side of crack, removing pavement, and placing a patch about two ft wide and extending across the runway. A reflection crack occurred down the center of the patch, so now there are three parallel cracks to maintain, spaced about one ft apart.

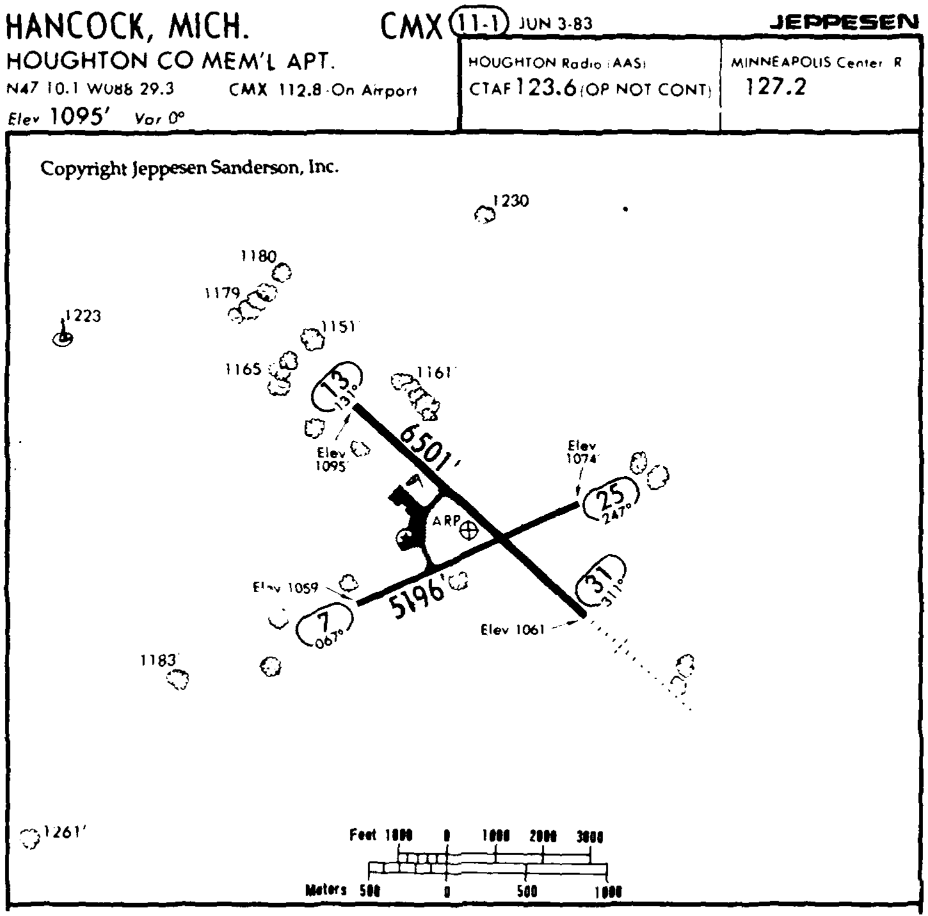
There are corner breaks and spalling on the PCC pavement, and general spalling of the PCC slabs, perhaps concentrated in a band parallel to the joint and about two ft wide.

On the bituminous pavement, there was a wide opening of the cracks. The filler did not fail, but it remained bonded so that it pulled the pavement and caused secondary cracking parallel to the original crack a fraction of an inch to a few inches away. The cracking was quite regular at a 50 to 75 ft spacing on the taxiway parallel to runway 10-28.

Before the overlay, there had been a problem of pavement shoving under turning movements. To correct this, a stiffer mix was used on the runway overlay (lower penetration asphalt). There is no evidence of shoving with this new mix. Also, the grooving has held up very well. However, this has resulted in more severe cracking on the runway than on the taxiway, where a medium penetration asphalt was used.

When a "Meadows" sealant was used, the secondary cracking did not occur, as this is a softer seal and has better extension characteristics. This sealant was first used two years ago (1983) as an experiment. It sticks well to the sides of cracks. Cracks may be as deep as 14 to 18 in. as measured with a tape; therefore, they probably go through the base.

PCC slabs in the apron area are about 25 by 25 ft and were placed in 1960. In addition to the corner breaks and spalling noted, many of the slabs are cracked completely across at the mid-point.



<u>Site Visitation Group</u> Visitation Date: 18 June 1985

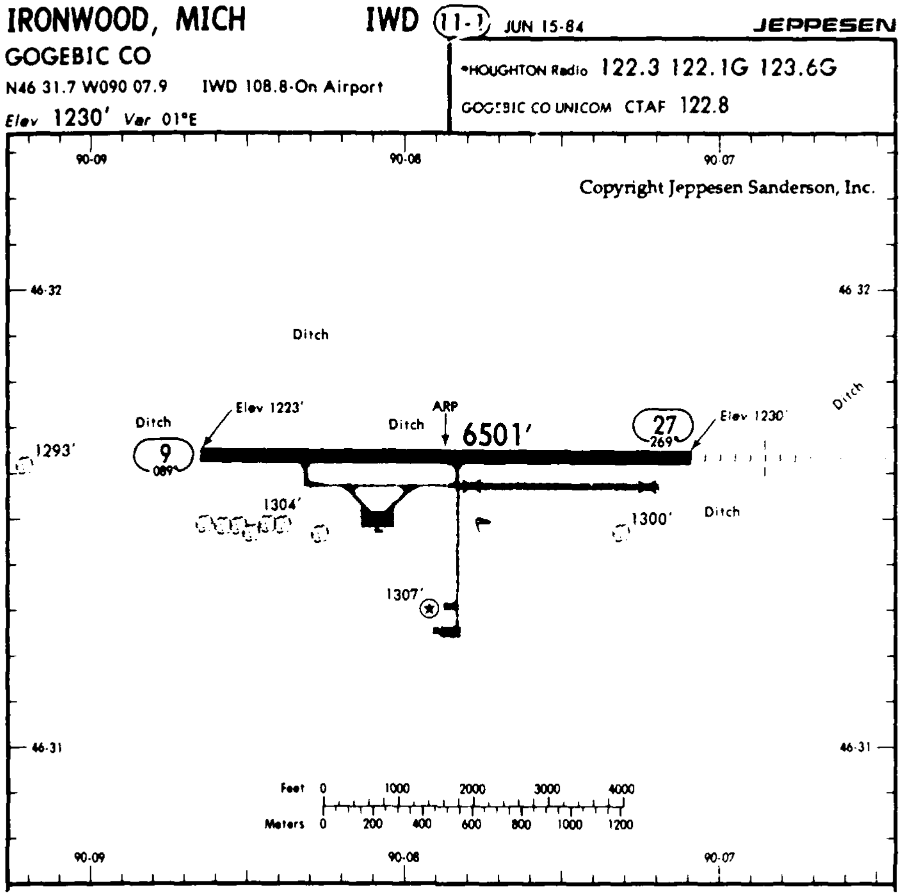
R. Berg, T.S. Vinson, I. Zomerman, USACRREL; T. Tomita, FAA; W. Haas, Mich. Tech. Univ.; A. Hagman, Airport Manager; R. Peckham, Peckham Engineering; R. Rought, Mich. Aeronautics Commission.

<u>Description of Airport</u> FAA Region: AGL AAAE Region: NC

In 1976, Runways 7-25 and 13-31 were completely rebuilt. The structural section consisted of 3 in. AC (P-412-9A) over 6 in. crushed base course (P-209) over 51 in. granular fill (P-154). In 1983, both the main and crosswind runways were overlaid with a 2 in. AC surface course (P-412-25A) and 3-1/2 in AC binder course (P-412-9A). The former AC surface was cold milled to a thickness of 1/2 in. and recycled into the binder course.

<u>Discussion of Problems</u>

Reflection cracks appeared in Runway 13-31 approximately 6 months after it was overlaid. Runway 7-25 also experienced reflection cracks but they were not as severe. Runway 13-31 has snow removal on a continual basis whereas 7-25 does not have continual removal.



Site Visitation Group Visitation Date: 18 June 1985

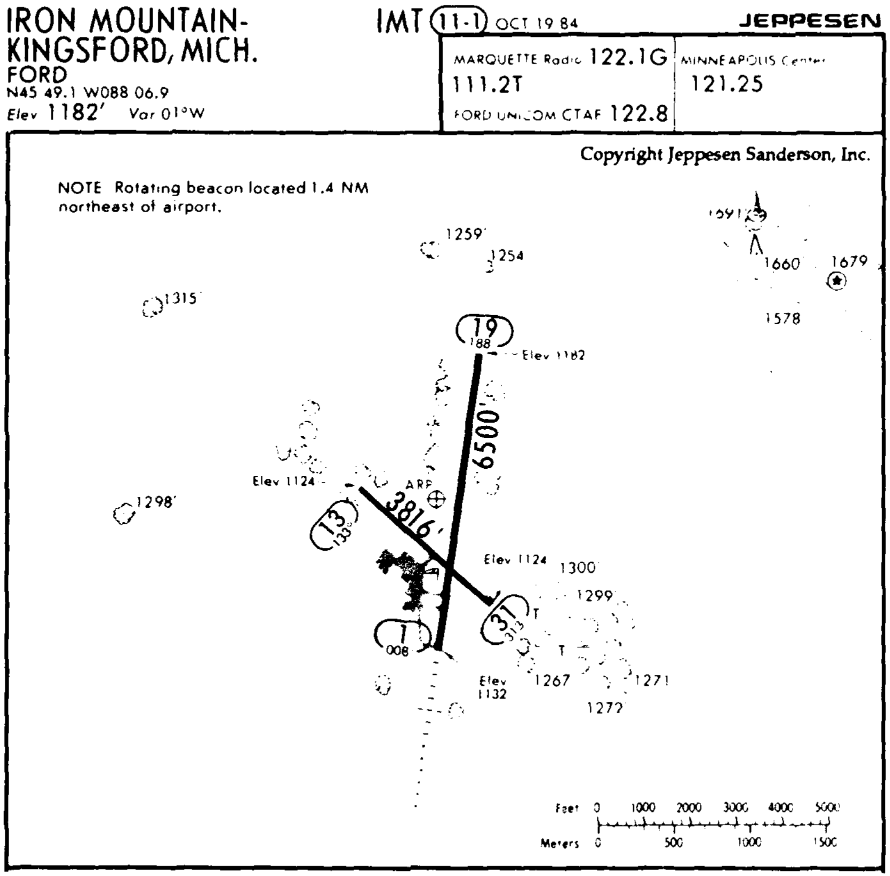
R. Berg, T.S. Vinson, I. Zomerman, USACRREL; T. Tomita, FAA, W. Haas, Mich. Tech. Univ.; R. Rought, Mich. Aeronautics.

Description of Airport FAA Region: AGL AAAE Region: NC

Runway 9-27 was reconstructed in 1979. It consisted of a 5 in. AC surface (MAC-412) over 8 in. aggregate base (P-209) over a 47 in. granular fill (P-152-E-2). The granular fill was surrounded by a poor draining cohesive soil. A drainage system was planned but not installed during initial construction.

Discussion of Problems

The poor cohesive soil surrounding the granular fill created a "bathtub" beneath the runway. Surface waves appeared in the runways when Convair 580s landed and "check" cracks were created in the AC surface. The problem was corrected when an underdrain system was installed. Both longitudinal and transverse cracks were observed in the runway.



<u>Site Visitation Group</u> Visitation Date: 18 June 1985

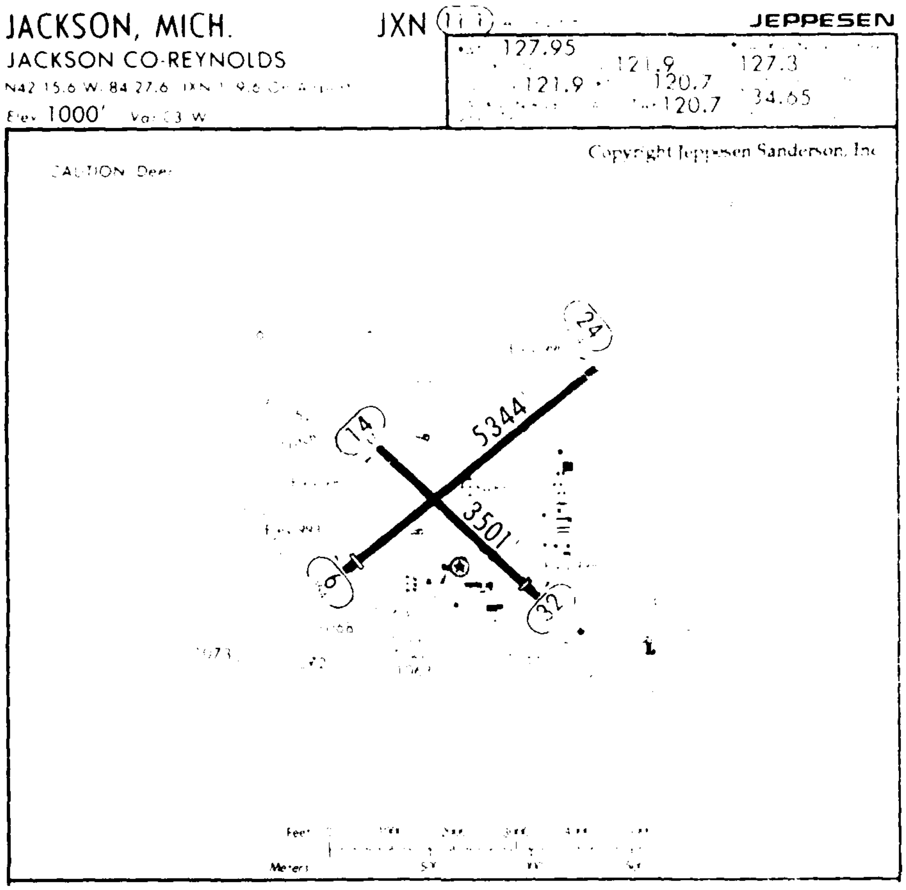
R. Berg, T.S. Vinson, I. Zomerman, USACRREL; T. Tomita, FAA; W. Haas, Mich. Tech. Univ.; R. Rought, Mich. Aeronautics Commission.

<u>Description of Airport</u> FAA Region: AGL AAAE : NC

The AC runways at the Iron Mountain airport were originally constructed between 1950 and 1969. In 1979, Runway 1-19 was completely recycled and Taxiways C and D were overlaid. The section consisted of 4 in. recycled AC (P-411), 9 in. aggregate base (P-209) over 3 in. subbase (P-208) over an E-2 subgrade soil.

<u>Discussion of Problems</u>

The north end of Runway 1-19 was severely cracked for approximately 2000 ft within three years of the recycling/reconstruction in 1979. Cracks started to appear one year after . A crack survey was conducted in 1982. A sealcoat with latex added to the asphalt cement has been used in the parking apron area with good success.



Site Visitation Group — Visitation Date: 5 August 1985

I. Zomerman, USACRREL; Randy L. Coller, Manager, Jackson County Airport

Description of Airport — FAA Region: AGL — AAAE Region: NC

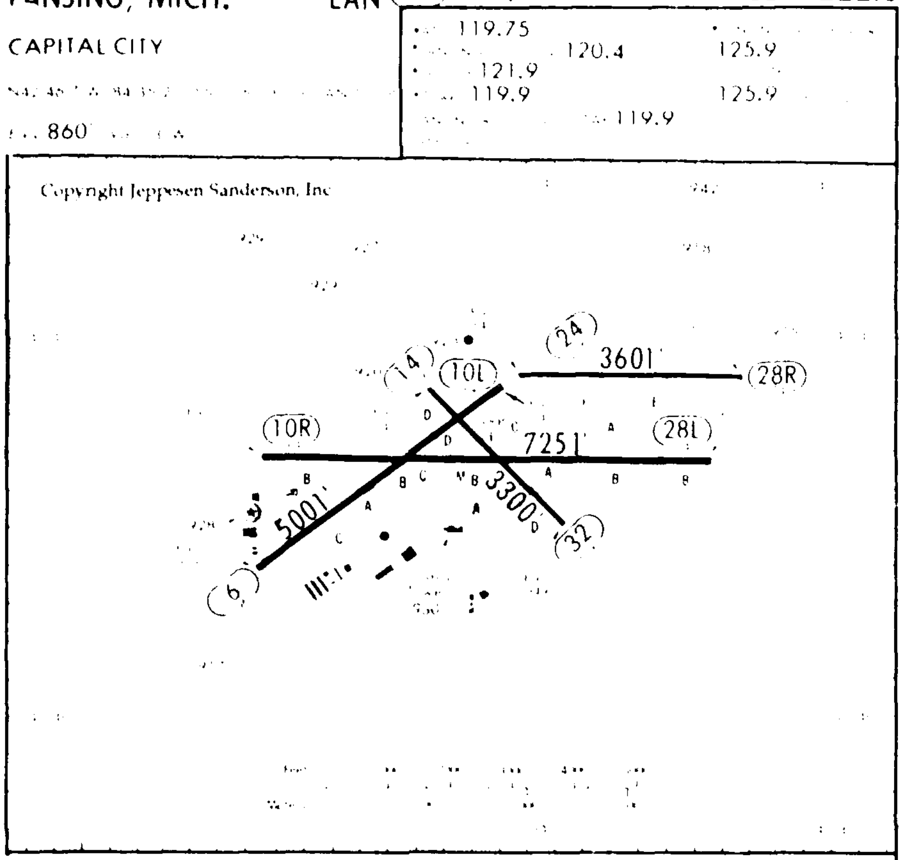
Only two of the original five runways built during World War II are still in service at Jackson County Airport. Runway 14-32 was single sloped and had pumping problems. This was corrected by crowning the runway. The runway is now being rebuilt to remove some of the frost susceptible material. Runway 6-24 was overlaid in 1972.

Discussion of Problems

The major structural problem with the runways is the lack of good base and subbase materials. Apparently the AC pavement was placed over clay. This has led to pumping problems even during relatively dry periods, frost heaving, and cracking. Over 19,000 lineal ft of runway have been overlaid in the past two years. Within five years, after runway 6-24 was overlaid, aggregate was popping out of the surface and cracking had occurred at most joints.
It was noted that there is an absence of braking action standards for general aviation airports.

LANSING, MICH. LAN JEPPESEN

CAPITAL CITY



Site Visitation Group

Visitation Date: 6 August 1985

I. Zomerman, USACRREL, Daniel J. Otto, Airport management.

Description of Airport

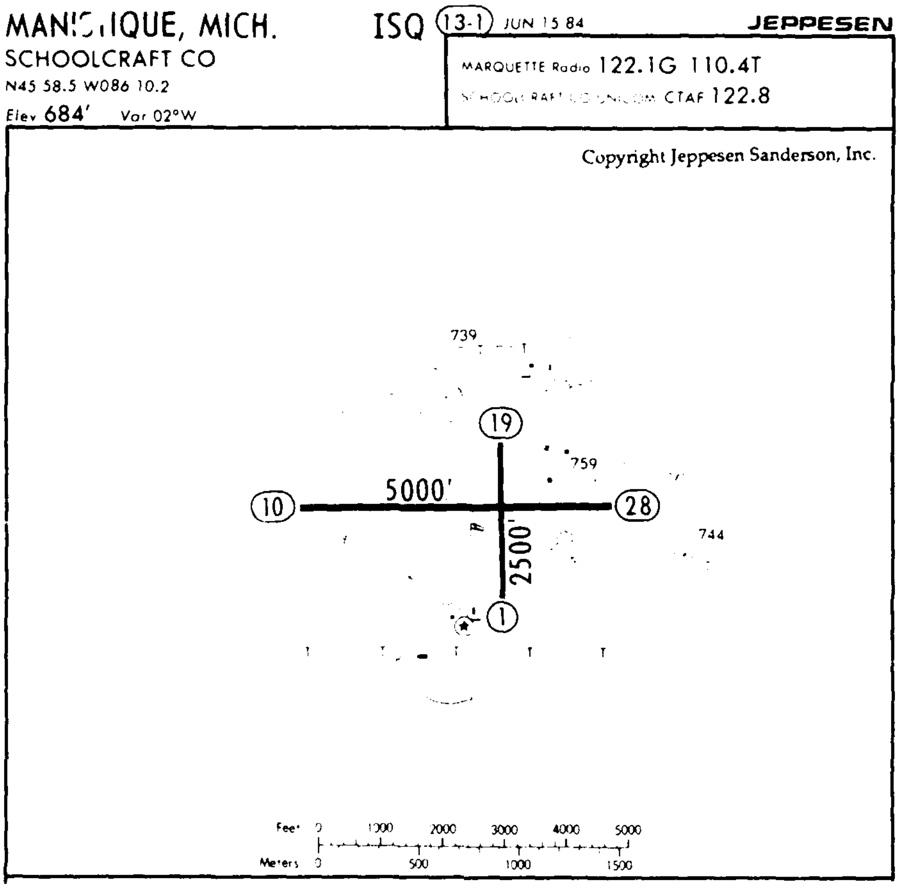
FAA Region: AGL

AAAE Region: NC

Capital City Airport was built in 1929 and was state run until 1971 when the airport authority took over. The airport had all PCC structures until 1973 when 90% of the airport was overlaid with up to 1 ft of AC. The two major runways have been grooved within the last three years. The ramp was milled off in 1983, because airplanes were sinking into it. It was replaced with a 9 in. non-bonded PCC overlay.

Discussion of Problems

The major problems consist of those common to most airports visited: reflective cracking, wildlife on runways, heaving of conduits.



Site Visitation Group

Visitation Date: 19 June 1985

R. Berg, T.S. Vinson, USACRREL; W. Haas, Mich. Tech. Univ.; W. Malinowski, Malinowski Engineering.

Description of Airport

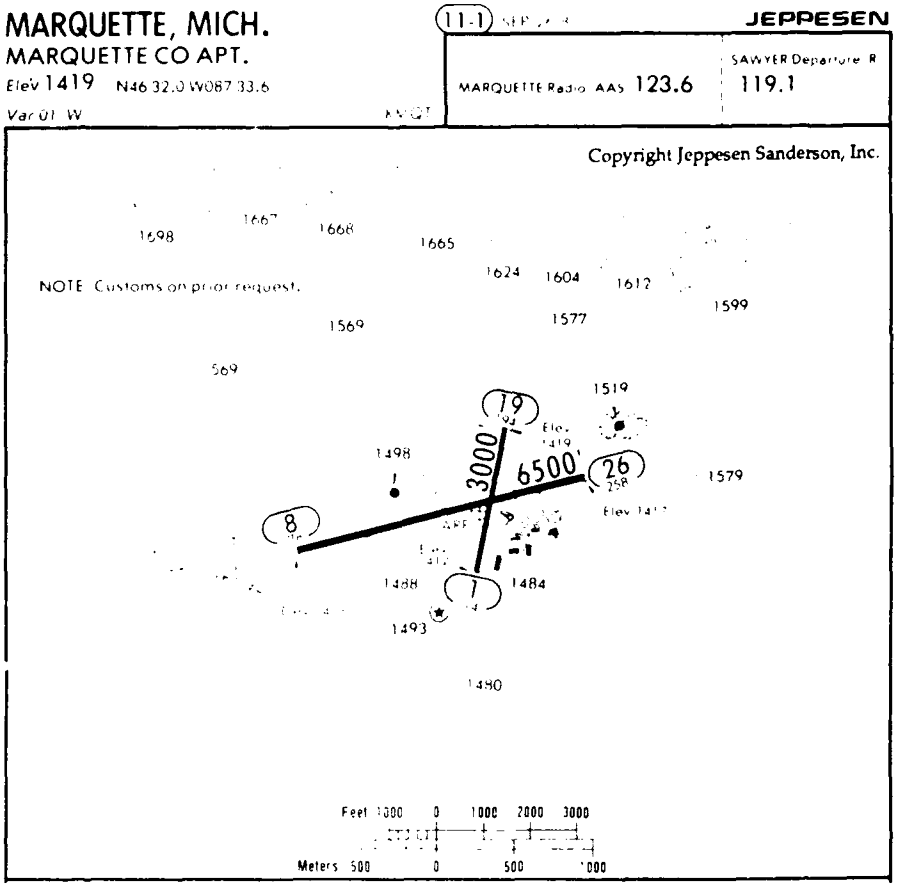
FAA Region: AGL

AAAE Region: NC

Schoolcraft Co. Airport was constructed in 1972. The pavement section consisted of 1-1/2 in. AC (P-412) over 6 in. aggregate base course (P-209). The entire airport is underlain by a free draining granular subgrade (E-2). In 1983, a condition survey was made of the airport pavement. The runways, taxiway, and apron exhibited numerous transverse cracks at approximately 60-ft intervals. Approximately 15,000 LF of cracking (1/4 in. to 1/2 in. wide) had occurred. In 1983, the runways, taxiway, and apron were reconstructed by grinding up and recycling the former AC surface and mixing it with course aggregate into the base (P-216 mod) (total recycled layer thickness ~ 4 in.) and surfacing with 2 in. AC (MAC 411) with 5% latex added to the asphalt cement. A sand seal coat was applied to the parking apron in 1984.

Discussion of Problems

On Runway 10-28, there were transverse cracks on the east end (28) but no transverse cracks on the west end (10) except at construction joints. On the north end of Runway 1-19, there were transverse cracks; on the south end there were faint to strong transverse cracks at spacings of 100 to 300 ft. The sand seal coat on the parking apron showed signs of distress. Cracks were present in the parking apron that apparently occurred over the past year.



Site Visitation Group

Visitation Date: 18 June 1985

R. Berg, T.S. Vinson, I. Zomerman, USACRREL; T. Tomita, FAA; W. Haas, Mich. Tech. Univ.; R. Rought, Mich. Aeronautics .

Description of Airport

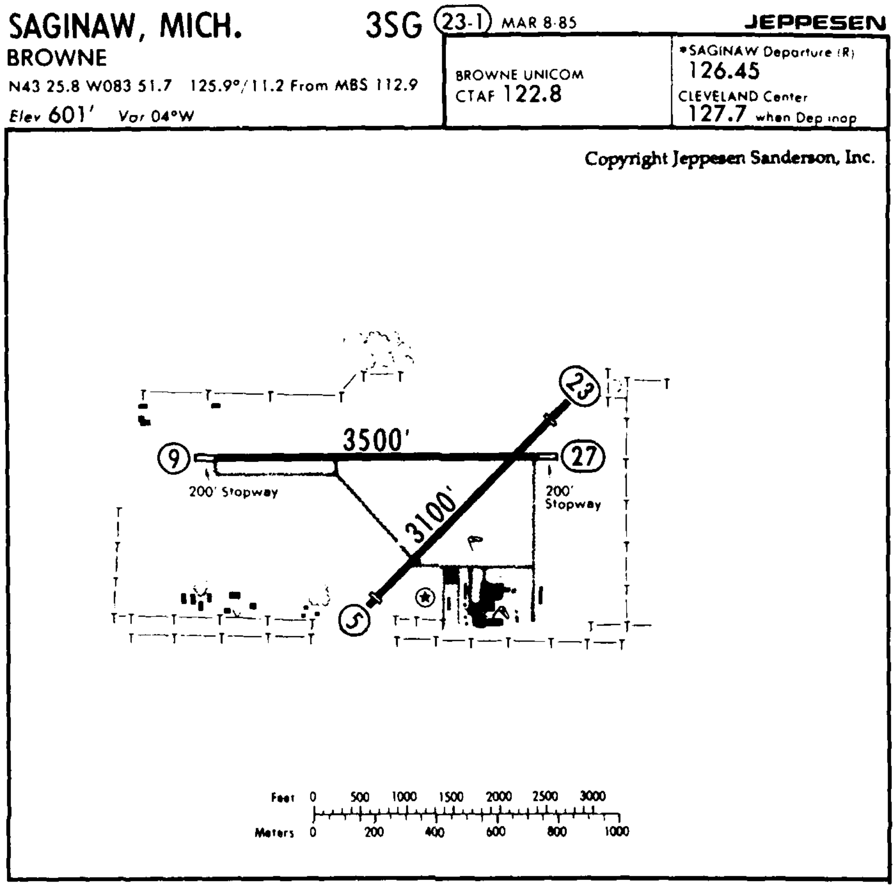
FAA Region: AGL

AAAE Region: NC

Runway 8-26 was reconstructed and widened in 1980. The section consisted of a 4 in. AC (recycled from previous pavement) (P-412-25A) over 8 in. crushed aggregate base (P-209). The entire airport is underlain by a free-draining sand subgrade For the reconstruction, the entire original AC surface was recycled down to the base course layer. In 1983, a 7/8 in. porous friction course (PFC) was placed over the above section. The PFC had 3% latex added to the asphalt cement.

Discussion of Problems

No major problems were observed. The PFC has performed very well.



Site Visitation Group

Visitation Date: 7 August 1985

I. Zomerman, USACRREL; Bob Peckham, Peckham Engineering (engineering firm for the airport).

Description of Airport

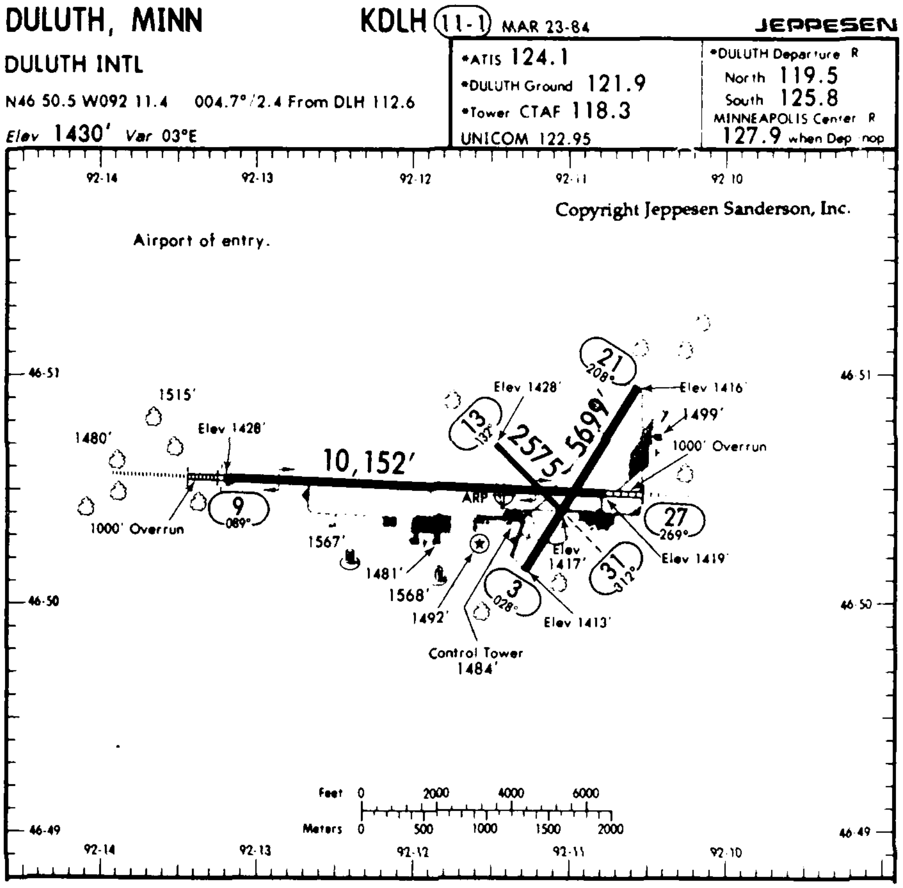
FAA Region: AGL

AAAE Region: NC

Tri-City Airport was built in 1942 by the Army Corps of Engineers. The structural design consists of a 7 to 10 in. W-section of PCC over a 24-in. sand base. The runways were overlaid in 1963 and again in 1975 for a total of 7 in. of AC. Underdrains were placed at the time of construction.

Discussion of Problems

Problems with frost heaving and FOD were observed. A substantial maintenance effort is required to keep these problems under control.



Site Visitation Group

Visitation Date: 16 August 1985

W. Haas, Mich. Tech. Univ.; Ken Wenberg, Duluth Airport Manager; Mike J. Spielmann, Minnesota DOT; Dagmar Runyon, Minnesota DOT.

Description of Airport

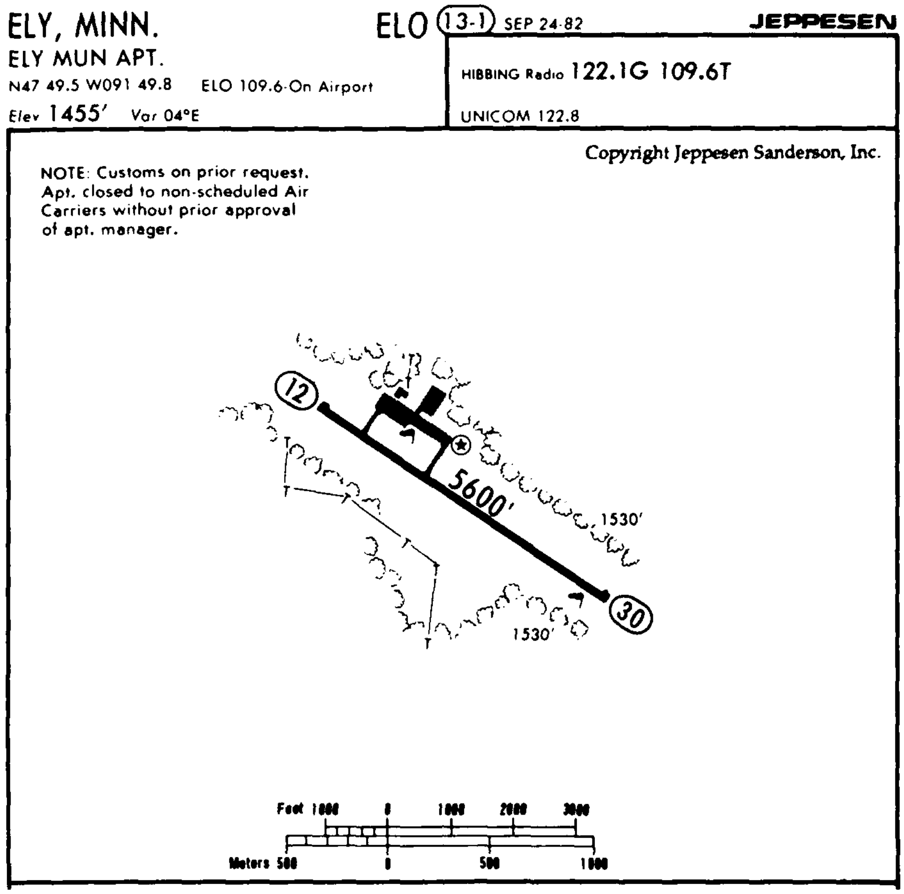
FAA Region: AGL

AAAE Region: NC

There are three runways at this airport, 10,152 ft by 150 ft (9-27), 5,700 by 150 ft (3-21), and 2,600 by 150 ft (13-31). Runway 3-21 was reconstructed in 1982, and the site visit concentrated on this runway, which is also discussed in the following section. Two scheduled carriers use Duluth. Republic operates Convair 580s, Boeing 727s, and DC-9s. Misabi, a regional carrier, operates F-27s. Charter flights using DC-10s also operate from Duluth. The Minnesota Air National Guard also uses this airport. C-130s and an occasional C-141 and C-5 will use runway 3-21. The F-4s do not use 3-21.

Discussion of Problems

Cracks reappeared about one year after reconstruction (overlay?). The crack filler generally performed quite well, but there are some instances where it pulled away from the sides of the crack, and also it tends to pull up by sticking to tires on a warm summer day. The crack filler in longitudinal cracks tends to partially defeat the benefit of grooving, as the sealer tends to block the grooves.



<u>Site Visitation Group</u> Visitation Date: 16 August 1985

W. Haas, Mich. Tech. Univ.; Mike J. Spielmann, Minnesota DOT; Dagmar Runyon, Minnesota DOT.

<u>Description of Airport</u> FAA Region: AGL AAAE Region: NC

The present airport at Ely was constructed in 1971 at a different location than the previous airport. It was given a bituminous pavement that same year. It consists of a single runway 5,600 x 100 ft (12-20).

This pavement developed transverse and longitudinal cracking to the degree that the pavement surface was broken into rough squares, typically 12 ft on a side, but with some as small as 4 ft In 1984, part of the runway was overlaid using a crack control fabric. Cracks were filled before placing the fabric, except for very narrow cracks. Most of the runway was reconstructed, using partly milled and recycled asphalt concrete for the base course, and new asphalt concrete for the surfacing. Also, at this time, areas of silt subgrade were excavated, one area to a depth of 18 ft, where an exceptionally bad transverse crack had developed. Also at this time, part of the apron area received an additional 4 in. of asphaltic concrete (P401) where converted bombers, used for fighting forest fires, were parked.

During the winter of 1984-85, transverse cracks formed in the area where the fabric was incorporated with the overlay. These were spaced about 200 ft apart and were up to 1/2 in. wide. During the present winter (1985-86), 75 percent of these same cracks have opened up to about 1/2 in.

In the reconstructed area, transverse cracks also formed at about 200 ft spacing, but they seemed to be narrower. During the winter of 1985-86, a few have opened to about 1/2 in. but about 75 percent of them are in the range of 1/16 to 1/4 in.

The Ely airport is primarily for general aviation, but it also supports another service vital to the area. During periods of forest fires, converted B-26 bombers are used to drop water on the fires. These aircraft use Ely as a base of operations. Other traffic has included an occasional C-119.

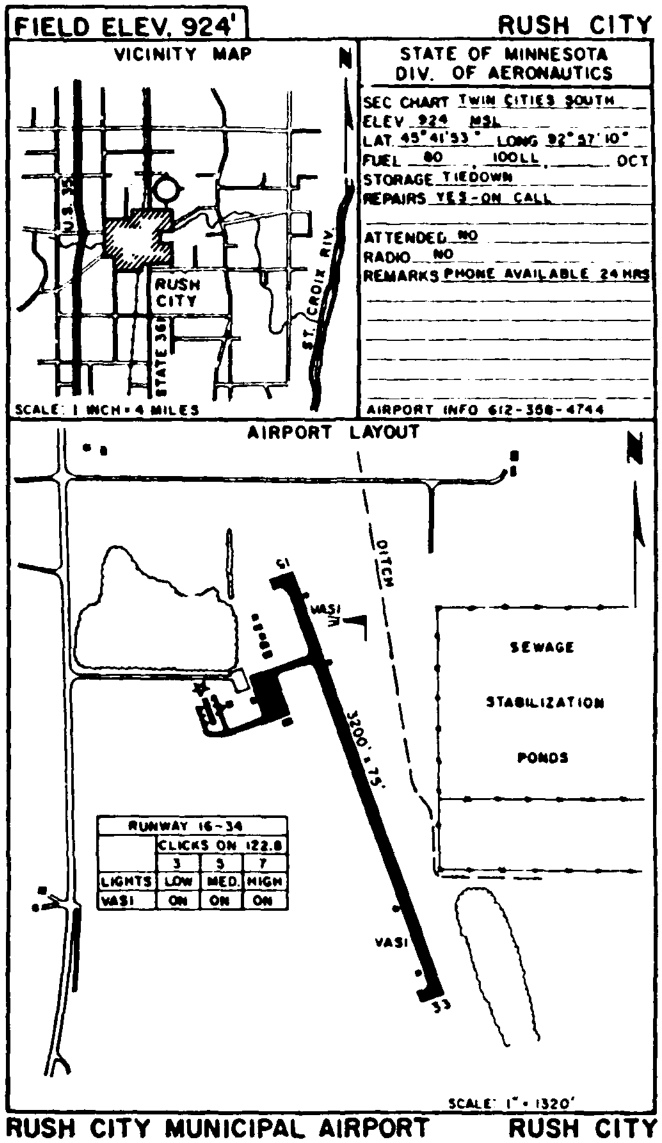
Discussion of Problems

The overlay put down in 1984 cracked during the first winter, and at the time of the site visit (August 1985) the reflection cracks had begun to show some secondary cracking, or ravelling of the edges of the crack, so that pieces of asphalt concrete on the order of 1/2 in. were being formed. This could possibly cause an FOD problem.

There was evidence of differential frost heave across some of these cracks, as evidenced by snowplow marks on one side of the crack.

White paint markings were deteriorating. The paint appeared to be lifting the asphalt concrete. Longitudinal cracks were appearing as well as transverse cracks.

On the apron area, a coal tar emulsion seal exhibited a crazed pattern of cracking (appearing like chicken wire). This is believed to be reflection cracking, following the pattern of cracking in the previous surface.



<u>Site Visitation Group</u> Visitation Date: 16 August 1985

W. Haas, Mich. Tech. Univ; Mike J. Spielmann, Minnesota DOT; Dagmar Runyon, Minnesota DOT.

<u>Description of Airport</u> FAA Region: AGL AAAE Region: NC

This airport consists of a single asphalt concrete runway 3,200 x 75 ft (15-33). The initial grading was done in 1961, with bituminous paving added in 1977. This consisted of 2 in. of asphalt concrete surfacing (P401) over a 4 in. aggregate base (P208 modified) over a 5 in. subbase (P154 modified). The top 6 in. of the subgrade was scarified and compacted. The subgrade is primarily clay, with a small portion trending to a silty/sandy clay.

A crack repair and sealing project was completed in 1980. Where transverse cracks appeared, the crack was isolated by sawing the pavement on either side of the crack and breaking out the pavement, possibly some of the base, and replacing with a bituminous patch.

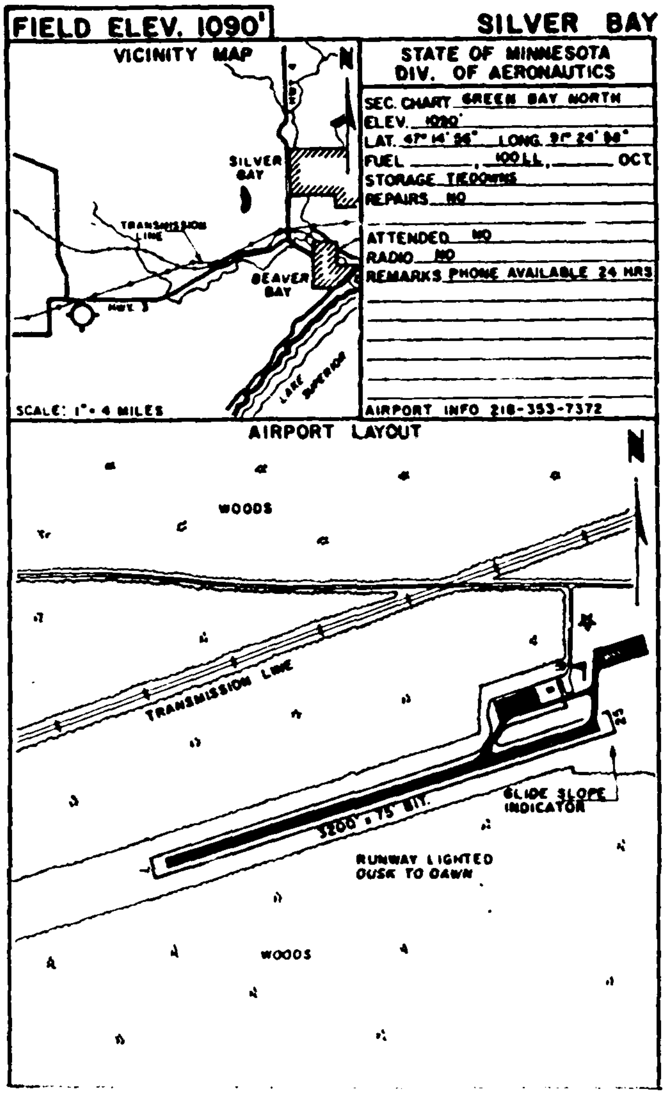
The airport is used for general aviation only.

Discussion of Problems

There is considerable transverse cracking evident (August 1985), and considerable longitudinal cracking, evidently at the joints in the paving lanes. In several cases, where a crack had previously been repaired by sawing out about a foot or so on each side of the crack, the crack reestablished itself down the center of the (approximately) two ft wide patch. Thus, there were three cracks where only one existed before the repair. Many of these extended completely across the runway. In addition, some cracks that were transverse to the centerline curved around to intersect other transverse cracks, somewhat in the manner of corner cracks on PCC panels. The combination of transverse cracks intersecting longitudinal cracks has resulted in additional cracks forming, similar to corner cracks on PCC pavements, with further cracking resulting in pieces as small as 1/2 to 1 ft across. Also, there is evidence of a bearing failure at the edge of the runway. In some cases where the first transverse crack has formed, a secondary crack has developed, more or less parallel to the first or original crack and about 6 in. from it, but curved like a D-crack so that the pavement is being broken down into relatively small blocks. Another condition is where the secondary crack is only 1-2 in. from the original crack, but the paving material is dropping into what must be a large crack in the base, but not readily visible from the surface.

There was also a problem with the white paint (forming the runway marker) peeling from the pavement and otherwise deteriorating.

The relatively flat topography, combined with the clay subgrade, suggest that the water content is naturally high at this site. It would be of interest to document frost heave and the development of differential heave at this airport, to determine if heaving contributes to pavement distress.



Site Visitation Group　　　　Visitation Date: 16 August 1985

W. Haas, Mich. Tech. Univ.; Mike J. Spielmann, Minnesota DOT; Dagmar Runyon, Minnesota DOT.

Description of Airport　　　　FAA Region: AGL　　　　AAAE Region: NC

This airport consists of a single 3200 by 75 ft runway (7-25) plus short taxiway leading to the apron and also to a hangar area. The pavement (runway and taxiway) was constructed in 1967. The design section consists of 1-1/2 in. of bituminous surface over 4-1/2 in. of base course over 9 in. of subbase. The natural soil is probably a plastic clay, based on exposed soil along the drainage ditch along the north side of the runway. A consultant's report refers to "fill material is 'Fat Clay - soft to medium'. Water was evident in the base on two borings."

This airport is used for general aviation, with a small number of light aircraft based there.

Discussion of Problems

The principal problem is that 17 transverse cracks, completely across the runway, developed by 1978. The crack widths varied, but some were as great as 12 in. In the summer of 1978, the city repaired the runway by sawing the 1-1/2 in. pavement at the top 2-1/2 in. of the base on both side of the crack, removing the material to a depth of 4 in. and replacing it with 4 in. of bituminous surface course.

The runway was overlaid in 1980, and at that time, only two years after the crack repair, the cracks were again evident, apparently at the same location. The overlay contract had a provision for crack repair before the overlay was placed.

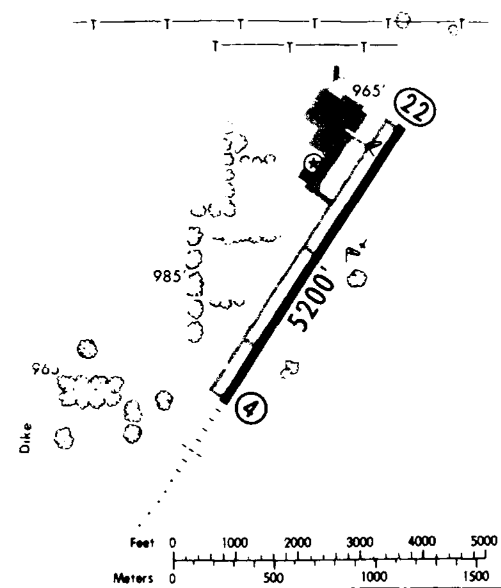
Cracks appeared in 1981, one year after the overlay, and have been gradually getting wider. At the time of the site visit (August 1985), expedient repairs had been made by using a patching compound, but this often did not completely fill the crack, as a tape could be put through a hole in the patch and inserted to a depth of 5 in. or more. Because of the large width of these cracks, the paving material is beginning to slump into the cracks. From the engineer's file, it appears that these cracks have occurred at the original spacing and, thus, at probably the same location.

It was also noted in August 1985 that in some spots, the transverse cracks were much closer, in some cases down to less than 10 ft spacing.

With the relatively thin pavement, and apparently high ground water conditions, it is likely that this pavement experiences considerable frost heave. This might be the reason why the longitudinal construction joints open up. It was noted that in some places the centerline joint was open while at other places the joints adjacent to the centerline, both left and right, were open while the centerline joint was tight. There is evidence of differential heaving at the transverse cracks, as shown by snowplow marks.

COLUMBUS, OHIO 2I4 (41-1) MAY 4-84		JEPPESEN
BOLTON N39 54.1 W083 08.2 241.6° 29.4 From APE 116.7 Elev 905' Var 03°W	*BOLTON Ground 121.8 *Tower CTAF 119.0 UNICOM 122.95	COLUMBUS Departure (R) 120.05

NOTE. Rwy 22 right traffic pattern when Twr inop



Site Visitation Group

Visitation Date: 12 September 1985

W. Haas, Mich. Tech. Univ.; Pat Hughes, Ohio Division of Aviation; Dick Butch, Ohio Division of Aviation; Bob Walters, Maintenance Supervisor, Bolton Field.

Description of Airport

FAA Region: AGL

AAAE Region: NC

Bolton Field has a single asphalt runway, 5200 by 100 ft (4-22). It serves charter, repairs, flight school, instruction, rental activities, and corporate aircraft. The original runway construction, 4200 ft long, was in 1969 and 1970. The pavement design is to FAA standards.

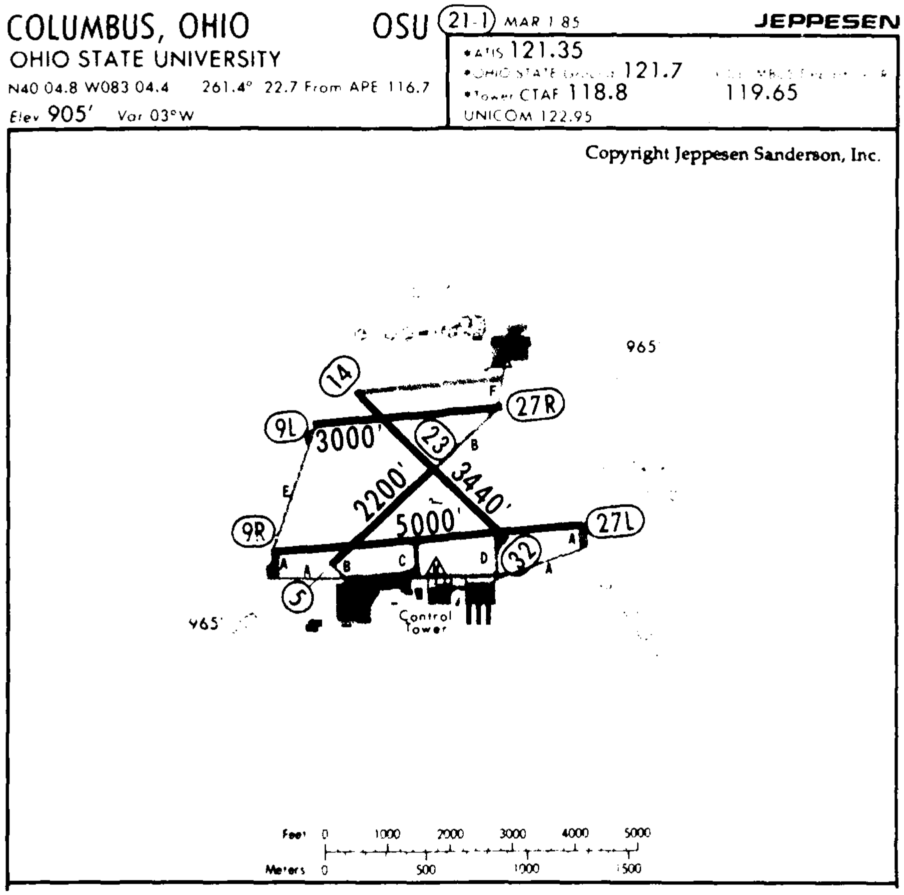
Discussion of Problems

The runway and the taxiway at the SW end were extended by 1000 ft in 1975. The extension of the taxiway is showing some longitudinal cracking, very likely at the paving lane joints, which have been sealed. In addition, there are a few examples of random transverse and longitudinal cracking over short distances. The runway is in good condition.

Near the NE end of the taxiway there is also some cracking which has been sealed. As this is primarily longitudinal, but irregular, it is not clear if it is following the construction joints or not.

The PCC apron area has experienced considerable spalling, especially at the slab corners of the panels, and also along the full length of some edges.

Bolton Field has also had problems with stormwater drains, especially in the hangar area. At the time of the site visit (September 1985), several of the drains were raised above the surrounding asphalt pavement by as much as 2 in. Thus, they do not function very effectively as drains until the water reaches that depth. Some have been repaired for drainage purposes (and to reduce the bump) with the asphalt ramps or fillings. In some cases, the PCC is badly deteriorated, and there is considerable evidence that the corners of the concrete have been struck by snowplows. It is not clear if the pavement has settled or if the drains have heaved.



<u>Site Visitation Group</u> Visitation Date: 12 September 1985

W. Haas, Mich. Tech. Univ.; Pat Hughes, Ohio Division of Aviation; Dick Butch, Ohio Division of Aviation; Gus Custer, Maintenance Superintendent, OSU Airport.

<u>Description of Airport</u> FAA Region: AGL AAAE Region: NC

The first runway constructed at this airport is the present 9R-27L, in a shorter version, in 1945. This runway was subsequently extended to its present length and width (5000x100 ft) and three additional runways were added: 9L-27R, 3000x100 ft; 5-23, 2200x100; and 14-32, 3040x100 ft. All are asphalt concrete. The pavement design is to FAA standards.

Although there are no commercial carriers operating at this airport, there is considerable traffic from high-performance medium weight jets. This field also serves some military aircraft. The Ohio National Guard operates helicopters from this field. The Air Guard operates a variety of aircraft, and occasionally C123s or F27s. In all, approximately 300 aircraft are based here.

<u>Discussion of Problems</u>

There were a number of catch basins that were heaved, and the airport management has an ongoing reconstruction program to correct this situation. In addition to the heaving, there was deterioration of the concrete at the top of the catch basins, where they were located in a paved area. It was noted that a catch basin of similar standard design, which was located in a grassed area, and several feet from the pavement, did not show signs of deterioration of the concrete.

The porous friction course on one pavement with little traffic was examined (Runway 14-32). It was believed that the gradation (1 in. max particle size) was too coarse for the light traffic, and not having much working effect of traffic, it eventually became very open. This was followed by the potential danger of FOD due to freeze-thaw action breaking some of the aggregate loose from the surface. A slurry seal was subsequently applied to part of this pavement on an experimental basis to correct the problem and was considered a success.

COSHOCTON, OHIO 14Ø 13-1 AUG 30-85 JEPPESEN

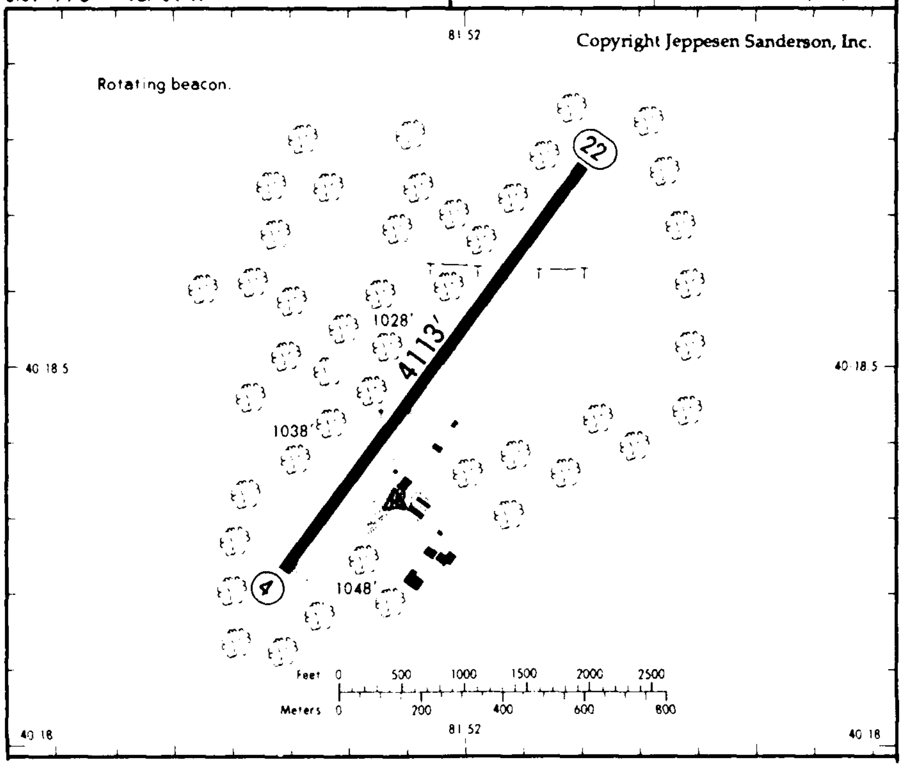
DOWNING

N40 18.6 W081 51.3 288.8° 18.0 From CTW 111.8

Elev 978' Var 04°W

DOWNING UNICOM
CTAF 122.8

*AKRON CANTON Departure R
118.6
INDIANAPOLIS Center R
124.45 when Dep inop.



Site Visitation Team

Visitation Date: 12 September 1985

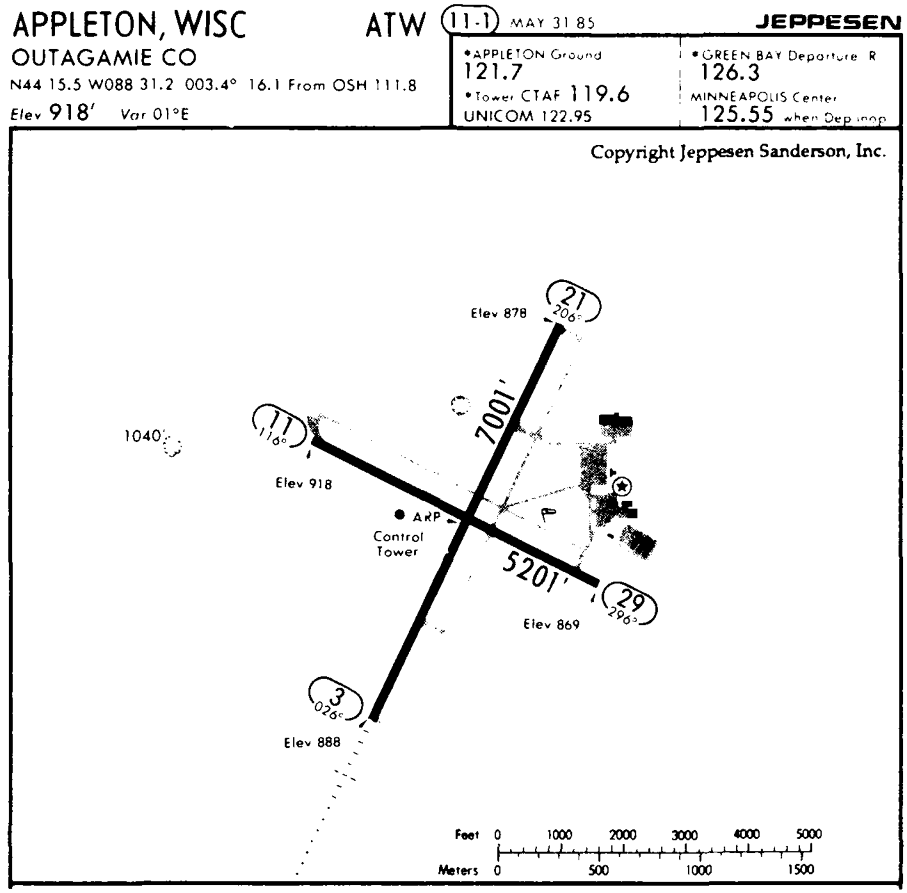
W. Haas, Mich. Tech. Univ., R. Benko, Regional Paving Engineer, FAA; Pat Hughes, Ohio Division of Aviation; Dick Burch, Ohio Division of Aviation; Rick Turner, Airport Manager, Richard Downing Airport; Coshocton.

Description of Airport FAA Region: AGL AAAE Region: NC

Coshocton Airport consists of a single asphalt concrete runway 75 by 4113 ft (4-22). The airport serves local light multi-engine corporate aircraft, and some charters. It was constructed on a deposit of soil from earlier strip-mining of coal. The design is 1-1/2 in. of AC over 5 in. of bituminous stabilized base. The airport was constructed in 1970, with additional taxiway construction more recently. The pavement is designed to Ohio standards for this class of airport.

Discussion of Problem

The main problem at the airport is with crack fillers. On a sealing project completed in September 1984, the blocking material had settled in many places one year later. In addition, the edges of the cracks had separated from the filler resulting in breaking/tearing of the edges, and the subsequent slumping of the filler into the crack. This suggests deep cracking, into the base course, as has been observed elsewhere.



<u>Site Visitation Group</u> Visitation Date: 21 June 1985

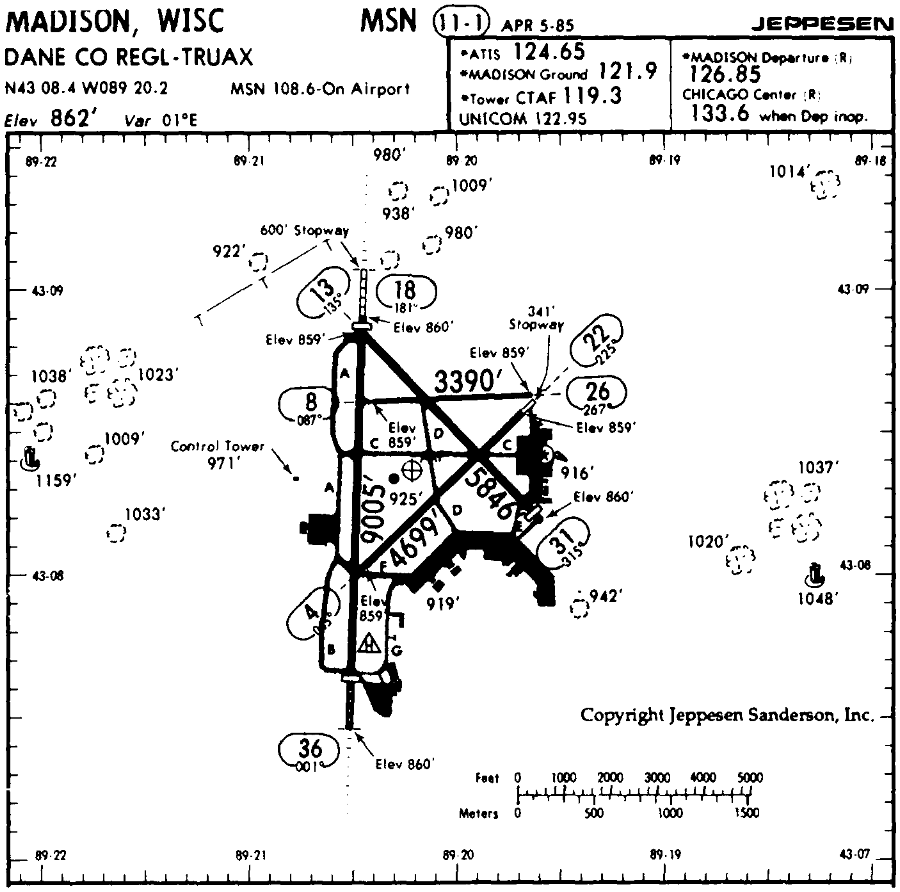
R. Berg, T.S. Vinson, I. Zomerman, USACRREL; T. Tomita, FAA; W. Haas, Mich. Tech. Univ.; R. Benko, Regional Paving Engineer, FAA; R. Kunkel, Chief Airport Development Engineer, Bureau of Aeronautics, Wisconsin; R. Kuha, Civil Engineer, FAA, Minneapolis; A. Fawley, Becher-Hoppe Engineers, Inc.; J. Hansford, Airport Manager, Central Wisconsin Airport, Mosinee, WI; A. Borchart, Airport Manager; T. Zimmer, Pavement Management Engineer, ERES Consultants, Inc., IL; and P. Becker, Division Manager, Mead and Hunt, Inc., WI.

<u>Description of Airport</u> FAA Region: AGL AAE Region: NC

The runways were originally constructed in 1968. The typical pavement section consists of 7 to 10 in PCC (P-501) over 8 in. of aggregate base (P-154). The subgrade is a silty clay to clayey silt (E-7). A 1000 ft extension to 3-21 was constructed in 1979.

<u>Discussion of Problems</u>

A condition survey was conducted in August 1982. At that time, the runways and taxiways were rated as good. On Runway 3-21 loss of load transfer, loss of aggregate interlock, and failures were noted. Based on a measurement made at the end of March 1985, a 7-1/2 in. differential movement was observed over a 75 ft length of PCC runway (near the intersection of 3-21 and 11-29); slab differential may be due to frost heave. A pilot comment was requested during the site visit. The pilot indicated the pavement was very rough during his landing.



<u>Site Visitation Group</u> Visitation Date: 21 June 1985

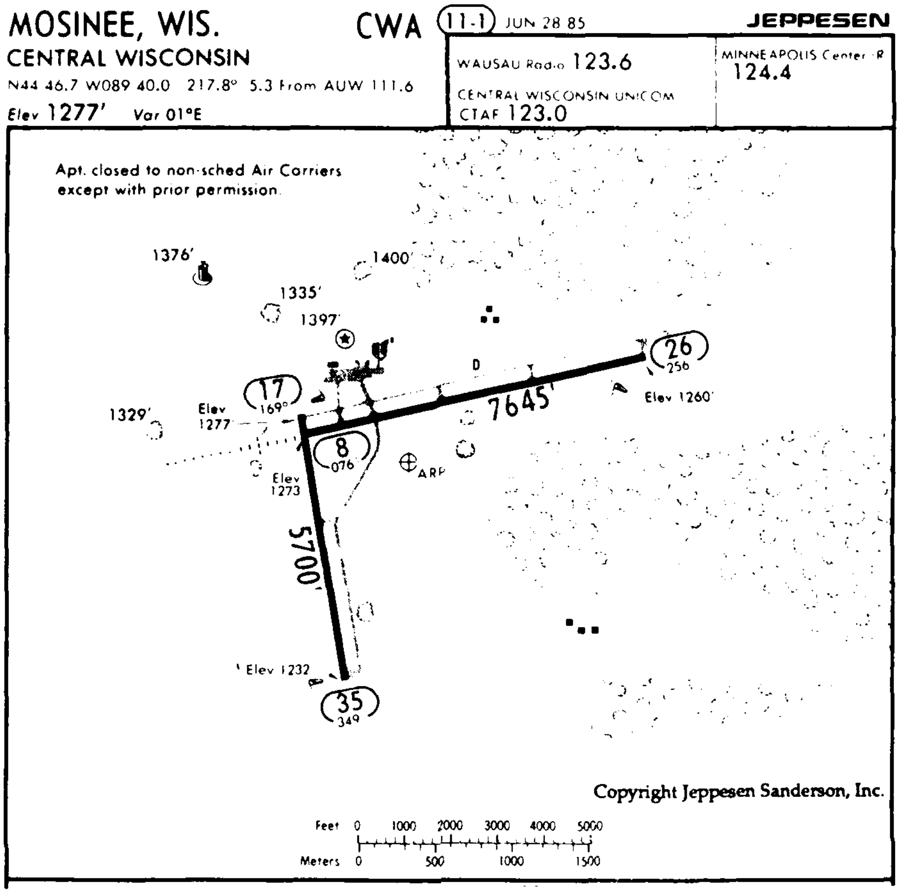
R. Berg, T.S. Vinson, I. Zomerman, USACRREL; T. Tomita, FAA; W. Haas, Mich. Tech. Univ.; P. Drahn , Airport Manager, R. Wood, Airport Maintenance Manager; R. Benko, Regional Paving Engineer, FAA; R. Kunkel, Chief Airport Development Engineer, Bureau of Aeronautics, Wisconsin; R. Kuha, Civil Engineer, FAA, Minneapolis; A. Fawley, Becher-Hoppe Engineers, Inc.; J. Hansford, Airport Manager, Central Wisconsin Airport, Mosinee, WI; and F. Gammon, Chairman, Commuter/General Aviation Airports Committee, AAAE and Director, Bureau of Aeronautics, Wisconsin.

<u>Description of Airport</u> FAA Region: AGL AAAE Region: NC

The airport was originally constructed during WWII. In 1972, 13-31 was reconstructed. The old pavement was broken up and 4 in. of AC was added to the pavement (additional aggregate was brought in to raise the crown). In approximately 1973, 18-36, the main runway, was constructed with 15 in. PCC. Runway 4-22 was overlaid in 1978. A seal coat was applied to Runway 13-31 in 1982.

<u>Discussion of Problems</u>

The airport manager has had excellent performance from the PCC pavement on Runway 18-36 but poor performance from the AC overlay on Runway 4-22. As a consequence of this experience, the manager will overlay Runway 4-22 with PCC within the next two years. There has been no major heaving on the runways but differential movement has been observed between old and new pavement areas on Runway 18-36. Frost heaving has been observed in the ramp area near the terminal and adjacent to the hangars.



<u>Site Visitation Group</u> Visitation Date: 21, 22 June 1985

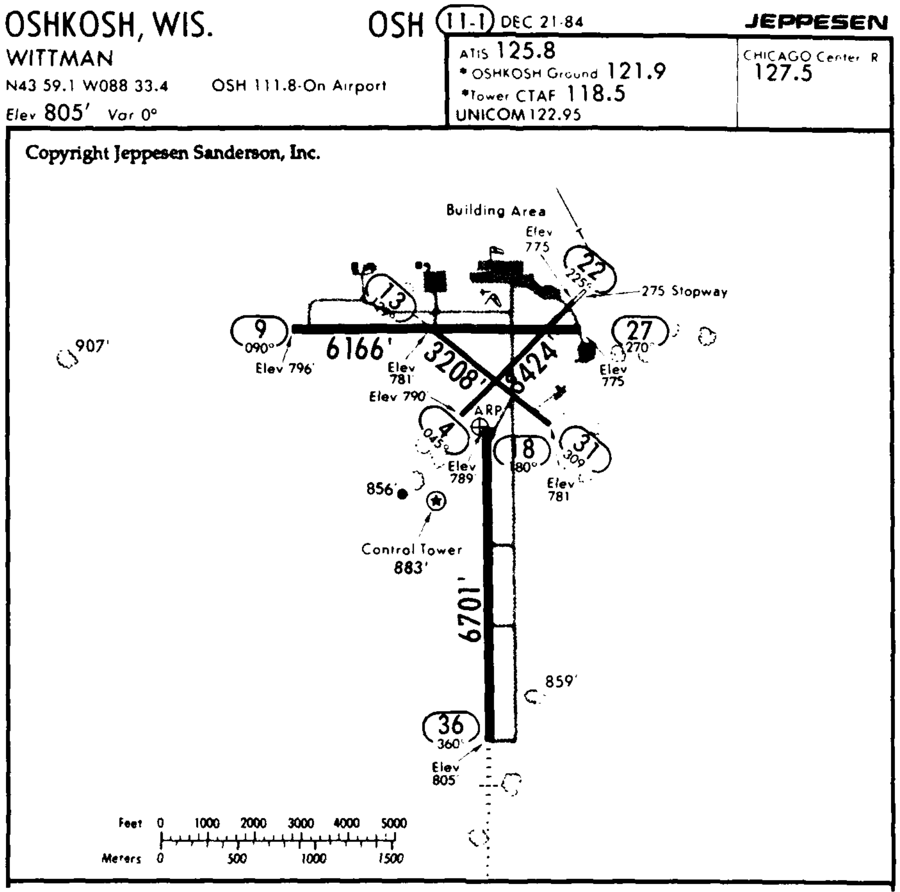
R. Berg, T.S. Vinson, I. Zomerman, USACRREL; T. Tomita, FAA; W. Haas, Mich. Tech. Univ.; and J. Hansford, Airport Manager.

<u>Description of Airport</u> FAA Region: AGL AAAE Region: NC

Runway 8-26 was constructed in 1968 and Runway 17-35 was constructed in 1973. Both runways have a similar structural section, namely, 10 to 12 in. of PCC (P-501), over 9 in. of aggregate base (P-208), over an E-6 subgrade soil.

<u>Discussion of Problems</u>

The runways, taxiways, and parking areas are in fair condition owing to cracking which has occurred in the PCC. The cracking is attributed to drainage problems. The areal drainage pattern runs from north to south beneath the parking area, taxiways, and runways. The airport manager has "shot" the rock underlying one runway to improve subsurface drainage. This appears to have been successful.



Site Visitation Group

Visitation Date: 21 June 1985

R. Berg, T..S. Vinson, I. Zomerman, USACRREL; T. Tomita, FAA; W. Haas, Mich. Tech. Univ.; R. Benko, Regional Paving Engineer, FAA; R. Kunkel, Chief Airport Development Engineer, Bureau of Aeronautics, Wisconsin; R. Kuha, Civil Engineer, FAA, Minneapolis; A. Fawley, Becher-Hoppe Engineers, Int.; J. Hansford, Airport Manager, Central Wisconsin Airport, Mosinee, WI; and D.Lewisen, Airport Maintenance Manager.

Description of Airport

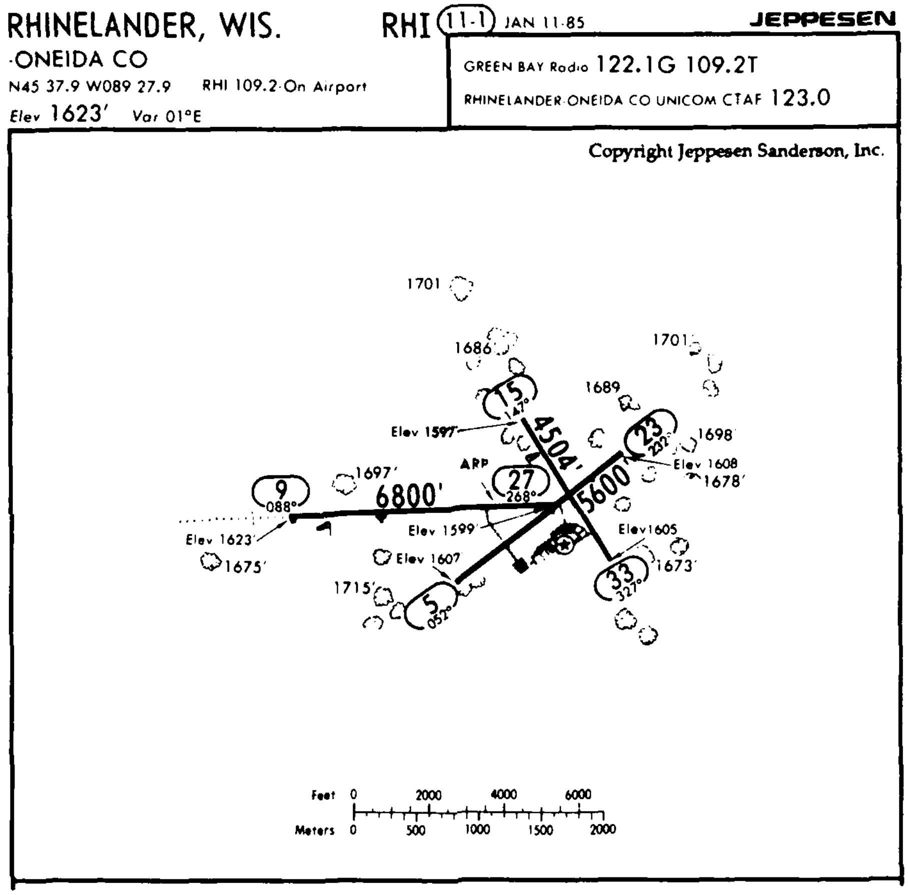
FAA Region: AGL

AAAE Region: NC

Runway 18-36 was constructed (reconstructed?) in 1965. It consists of 9 in. PCC over 10 in. of gravel base. Runway 9-27 was reconstructed in 1980. The pavement section of 4 to 5-1/2 in. of AC over a leveling course which is over 5 to 8 in. of old AC and 6 to 8 in. of old base course.

Discussion of Problems

No major problems were observed during the site visit. The airport maintenance manager indicated there were no frost heave problems. There was a pavement failure at the intersection of Runways 9-27 and 4-22 which was believed to be related to poor drainage in the area. A patch has been placed in this area.



Site Visitation Group Visitation Date: 20 June 1985

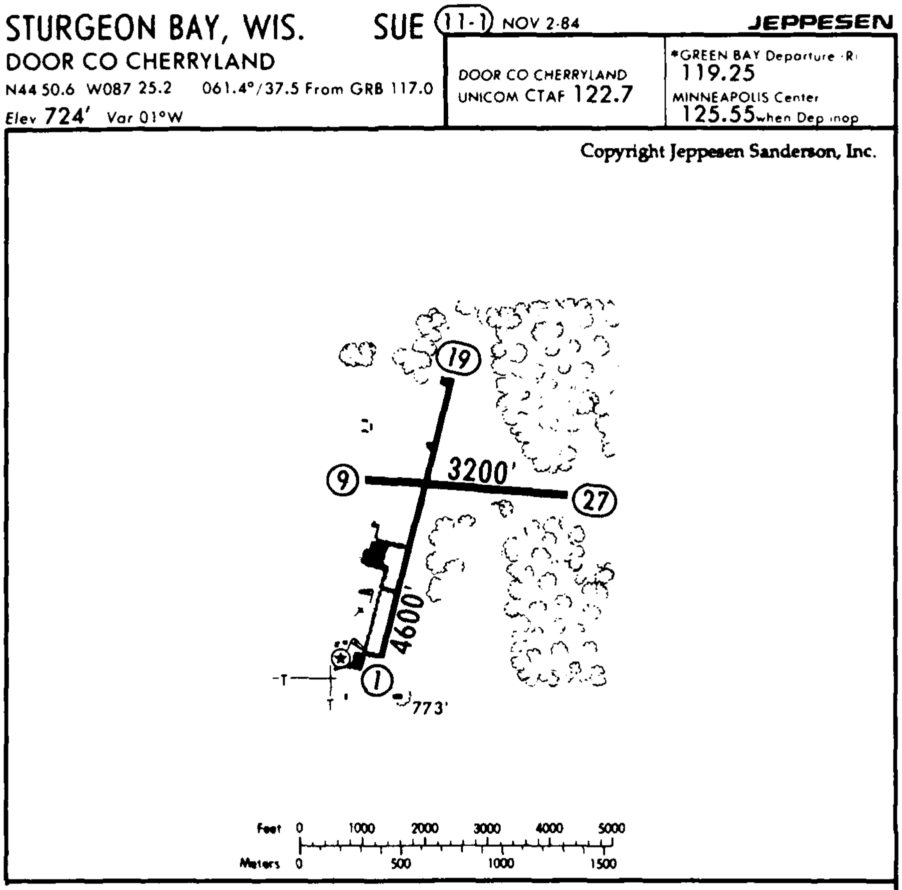
R. Berg, T. S. Vinson, I. Zomerman, USACRREL; T. Tomita, FAA; W. Haas, Mich. Tech. Univ.; and J. Chmiel, Airport Manager.

Description of Airport FAA Region: AGL AAAE Region: NC

Runway 5-23 at Rhinelander-Oneida County Airport was originally constructed in 1949. Runway 15-33 was constructed in 1956. Over the following twenty-two years, runways were lengthened, parking aprons and taxiways were paved, and in 1978, Runway 9-27 was constructed. Between 1966 and 1973, most of the pavement structure (in place) was overlaid. The existing surface for the airport is AC (P-401) with a variable thickness. In general, there are no drainage problems at the airport.

Discussion of Problems

Runway 15-33 has severe transverse and secondary cracks. The south end has "waviness" in the spring, but not to the extent that the runway must be closed. The airport authority would like to reconstruct Runway 15-33 within the next two years.



Site Visitation Group

Visitation Date: 22 June 1985

T.S. Vinson, I. Zomerman, USACRREL; and G. McQueen, Airport Manager.

Description of Airport

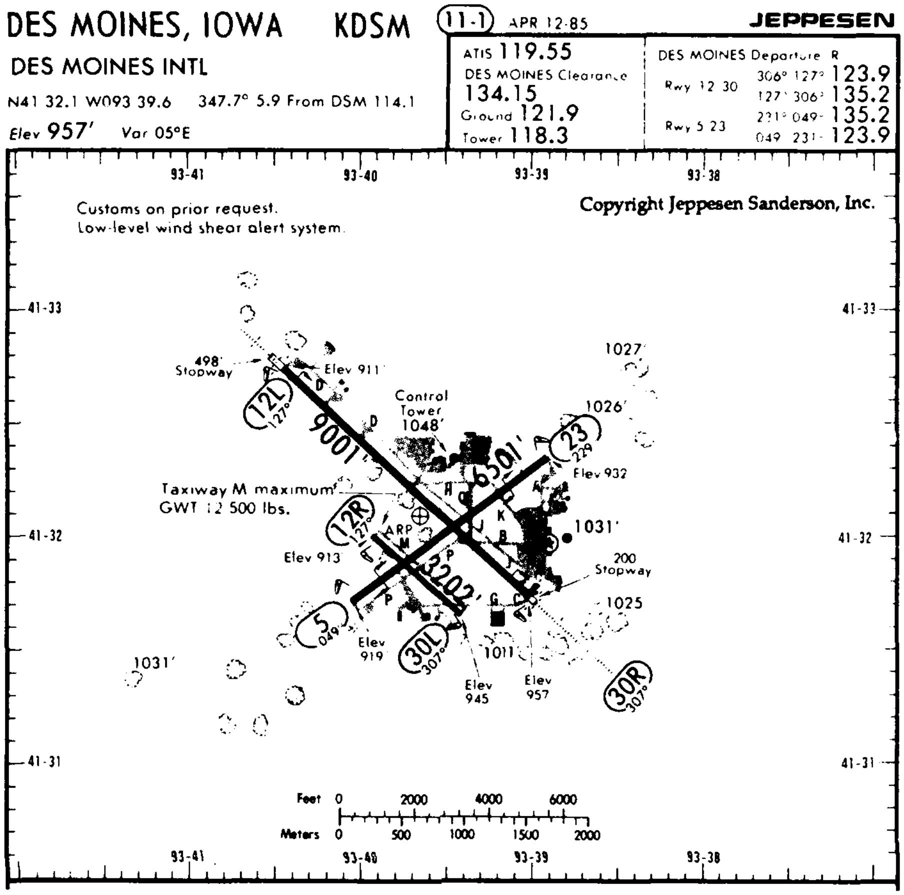
FAA Region: AGL

AAAE Region: NC

The original airport (Runway 1-19) was constructed in 1963. Initially, the structural section consisted of 9 in. of aggregate base over an E-7 subgrade soil. In 1976, Runway 1-19 was paved with 2 in. AC (P-401) and extended 1000 ft to the north. Runway 9-27 was constructed in 1984. The structural section of 2 in. of AC (P-401), over 9 in. of crushed aggregate base (P-209) over subgrade soil (E-7).

Discussion of Problems

A severe differential frost heave problem exists at a culvert crossing on Runway 1-19. The problem appears to be related to the fact that a frost susceptible material was used as backfill for the culvert. An electrical conduit crossing Runway 1-19 has minor differential movement.



Site Visitation Group

Visitation Date: 22 July 1985

W. Haas, Mich. Tech. Univ.; John M. Shonts, Operations Officer, Des Moines International Airport.

Description of Airport

FAA Region: ACE AAAE Region: NC

The pavements were constructed over a period of time, with overlays used to progressively upgrade to heavier aircraft. The initial design was for the DC-3. More recently, the Boeing 727 has become the design aircraft, but due to the overlays, the base is still designed for DC-3's. A pavement condition survey was conducted and a rehabilitation program developed and partly implemented.

Discussion of Problems

Pavement cracking is a severe problem at the airport. This was illustrated (in part) by an air photo mosaic of excellent quality, at a nominal scale of 1 in. to 100 ft. The extent of cracking was very clear on the mosaic, and it was used to obtain an estimate of the lineal feet of cracking to be repaired. This came out as 40 miles.

On the PCC taxiway parallel to one of the main runways, there was considerable evidence of distress in the form of cracking and spalling at the corners of the slabs, transverse cracks completely across the slabs at their mid-points or third-points, and some loose aggregate and concrete, potentially an FOD problem.

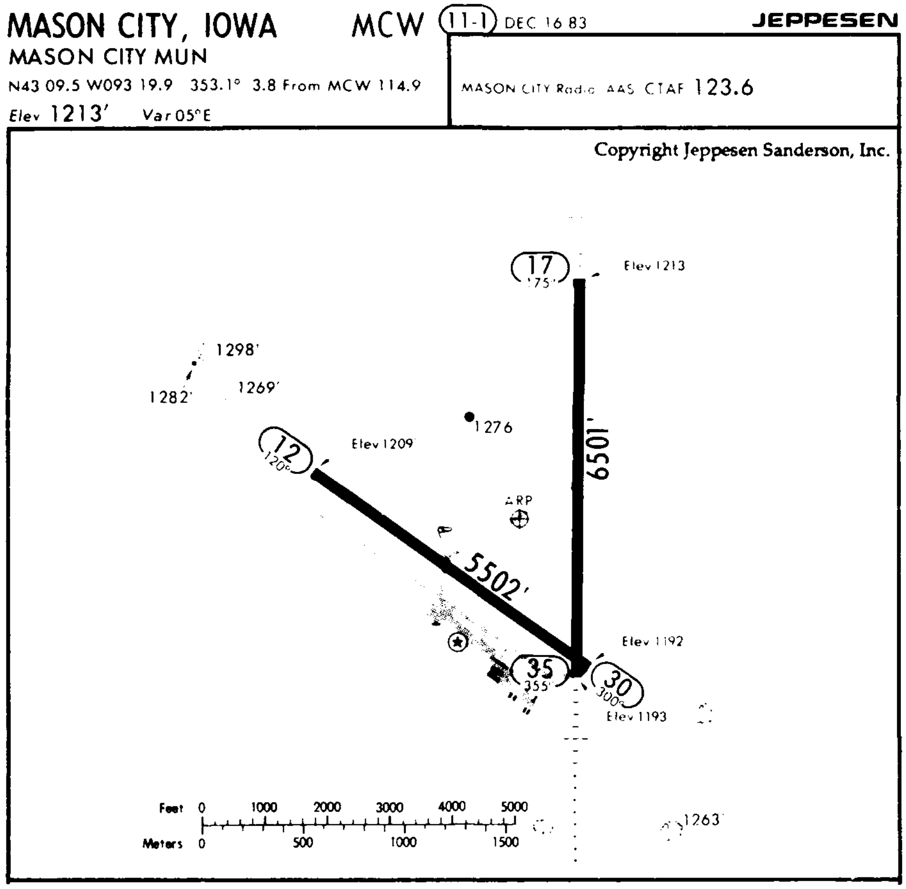
One of the older taxiways, "M", had been previously overlaid with asphalt and subsequently experienced reflection cracks 0.3 ft wide. Although an effort had been made to seal or fill these cracks, the surface of the sealer was 0.15 ft below the pavement surface, suggesting a deep crack as well as a wide one. The cracks typically extended across the entire taxiway. There was considerable longitudinal cracking on taxiway "M" in addition to the transverse cracking.

Sealer materials seem to be inadequate. In one location, the crack sealer bubbled up in the hot weather, and could be easily pulled away. Thus, the sealer material is readily pulled away by pavement sweeping operations, effectively destroying the seal. At another location, the sealer liquefied and drained lengthwise out of the crack and ponded on the pavement surface. (The pavement was on a slight longitudinal grade at this location.)

One of the taxiway segments scheduled for overlay was postponed because of delamination of the previous overlay. This was evidenced by a hollow sound when tapped, and by some actual removal of the overlay material.

Many of these problems can logically be considered to be due to cold temperatures. The airport manager stated that there were about 60 to 70 freeze-thaw cycles per season, and that the water table is high.

Subsequent discussion with the consultant's representative underscored the poor drainage. He stated that the design tended to create "ponds" and that there was no provision for draining the "rock" (subbase??) course under the pavement. Apparently when costs threaten to exceed the available funds, drainage is an item that is left out, or at least severely cut back.



Site Visitation Group Visitation Date: 23 July 1985

W. Haas, Mich. Tech. Univ.; George Brown, Airport Manager, Mason City Airport.

Description of Airport FAA Region: ACE AAAE Region: NC

The main runway (17-35) is 6,500 by 150 ft, and the crosswind runway (12-30) is 5,500 by 150 ft. Both were constructed with asphalt concrete in 1943-44. The taxiways are 75 ft wide. In addition to the original construction, additional work was done in 1948-49, 1968, and 1972. There are presently two regional carriers serving Mason City, providing connections to Minneapolis/St. Paul, Omaha, Des Moines, and Chicago. One uses the Beech 99, the other uses the Metroliner. Both are considering a change to the Beech 1900. In addition to this, the fixed base operation provides charter service.

Water standing in sand pits on an airport property provides evidence that the groundwater table is high.

Discussion of Problems

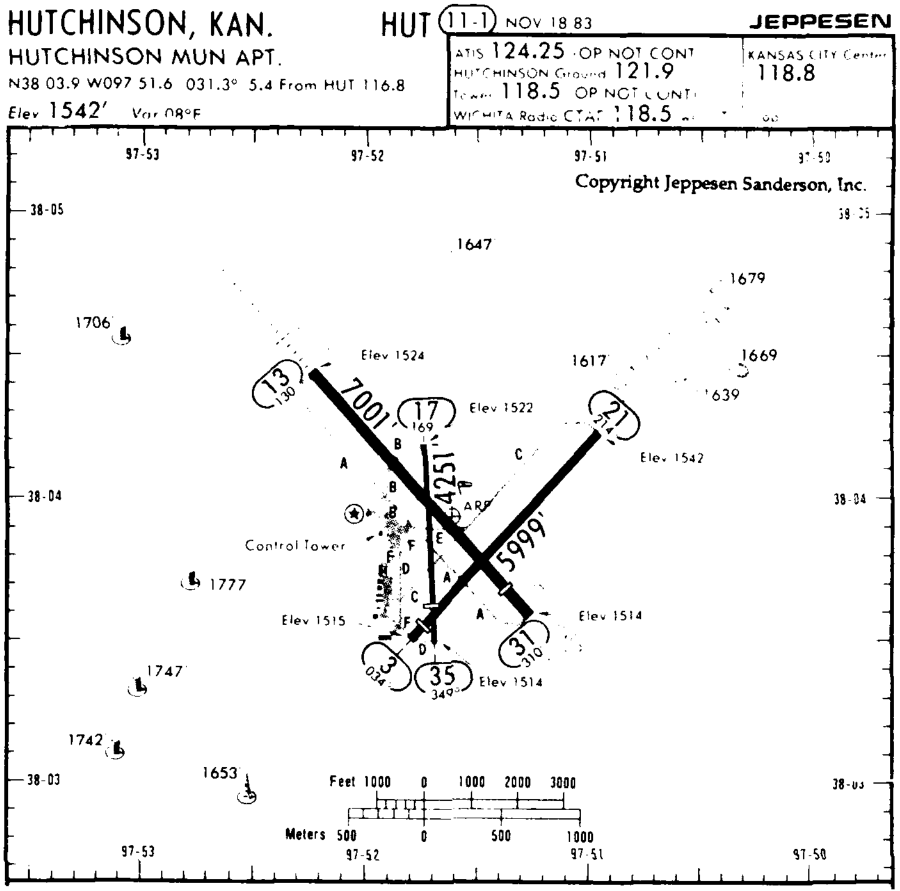
Reflection cracking was taking place in the overlay. The cracks were quite wide, and apparently quite deep. After the primary crack was well established, a secondary crack would form parallel to the primary crack and a few inches away. The surface would then settle below the established pavement level. This was perceived to be due to base course material breaking away and dropping deeper into the crack. In spite of the wide cracks, the crack filler material as holding in some cases.

In an attempt to prevent or at least mitigate this secondary cracking and collapse, dry sand is placed in the open cracks during the winter. This supports the sides of the crack and prevents the collapse and settlement of the pavement.

On runway 12-30, the reflection cracks in the overlay generally follow the saw cuts in the 3 ft wide patches made in the concrete before the overlay was placed. However, on runway 17-35, the transverse cracks were random in occurrence. Overall, cracking was worse on 17-35 than on 12-30.

A further problem was that the foam backing material floated out of the cracks in some cases. This could be taken as further evidence of high ground water conditions and inadequate drainage.

A crack sealing program was initiated in 1985, and temporarily halted in October 1985. It will be continued in 1986. The soft seal worked well, but the slurry seal tended to pull away from the asphalt surface at the crack.



<u>Site Visitation Group</u> Visitation Date: 24 June 1985

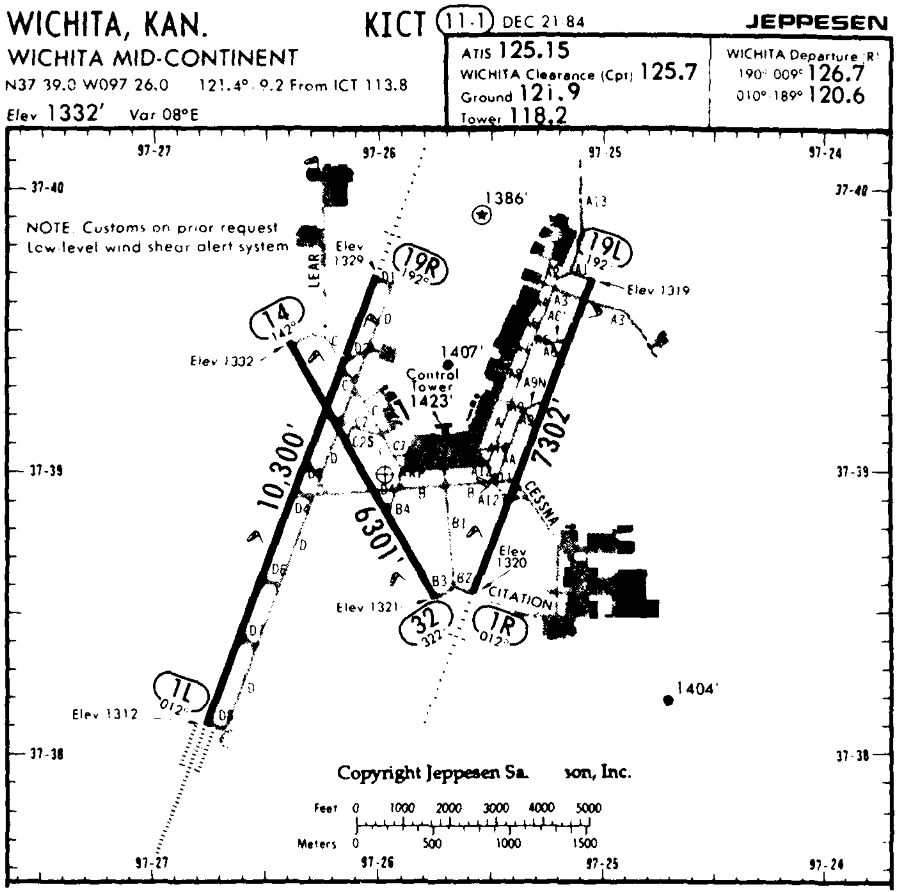
T.S. Vinson, I. Zomerman, USACRREL; and J. Black, Airport Supervisor.

<u>Description of Airport</u> FAA Region: ACE AAAE Region: SC

All runways, taxiways, and parking aprons were originally constructed between 1940 and 1944. Runway 17-35 is a 3-in. AC pavement over a 4 to 12-in. salt-stabilized gravel base. Runway 3-21 consists of 4000 ft of 3 in. AC over a 4 to 12-in. salt-stabilized gravel base and 2000 ft of 8 in PCC over the subgrade soil. Runway 13-31 consists of 4400 ft of 3 in. AC over 4 to 12 in. salt-stabilized gravel base widened 25 ft on each side with 8 in. PCC and 2600 ft of 8 in. over the subgrade soil. The taxiways and aprons consist of 3 in. AC over 6 to 12 in. of salt-stabilized gravel base. All AC surfaces were sealed in 1953 after the return of the airport to the city by the Navy. The AC seal added approximately 1 in. to the existing structure. Runway 17-35 was overlaid with 4 to 5 in. of AC in 1982. A taxiway was overlaid in 1984.

<u>Discussion of Problems</u>

The PCC pavements are in remarkably good condition considering their age. The PCC pavement does not exhibit any appreciable "D" or corner cracking. This is in sharp contrast to the PCC at Wichita which is only 30 miles away. A few cracks have reflected through the overlay on Runway 17-35. The underlying cracks have already reflected through the taxiway.



Site Visitation Group Visitation Date: 24 June 1985

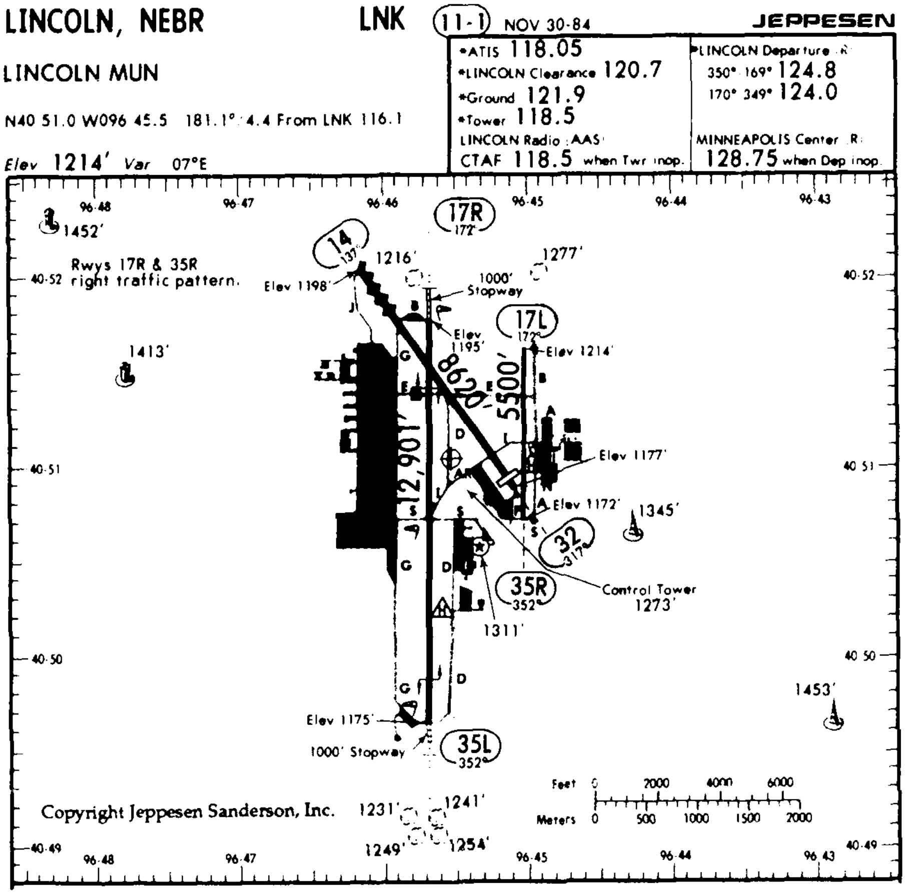
T.S. Vinson, I. Zomerman, USACRREL; and D. Henderson , Director of Airport Operations.

Description of Airport FAA Region: ACE AAAE Region: SC

The runways, taxiways, and parking areas are all PCC. The characteristics of the original pavement, probably constructed in the early 1950s, are not known. Runway 1R-19L was overlaid in 1979. Runway 1L-19E was overlaid and extended approximately 3000 ft in 1981. The thickness of the overlay and new PCC is 12 in.

Discussion of Problems

Severe "D" cracking and general corner cracking exists throughout the airport. In some areas a "patchwork" of repairs exists with initial patches failing followed by subsequent patches failing at the interface of an AC patch with a PCC slab. A number of slabs have been replaced entirely. The airport provides an unfortunate example of the problems associated with maintaining a PCC pavement once it starts to experience slab corner failures. There is increased roughness of the pavement in the winter associated with minor differential frost heave. Water pumps through cracks and joints and has caused joint compound material to be ejected.



Site Visitation Group

Visitation Date: 24 July 1985

W. Haas, Mich. Tech. Univ.; Carl Rienstra, Nebraska Department of Aeronautics; Diane Hofer, Nebraska Department of Aeronautics.

Description of Airport

FAA Region: ACE

AAAE Region: NC

This airport was originally constructed in the early 1940s as a military airfield. When it was decommissioned in 1965, it was handling B47s. Civil aviation commenced in the 1950s, when the field was shared with the U.S. Air Force. At the present time this airport has about eight carriers, both regional and transcontinental. The largest commercial aircraft using the field is the Boeing 747.

There is continued military usage of the field. The Nebraska Air National Guard operates F-4's and other aircraft, the Army has a helicopter unit based at the field, and it serves as an alternate field for Offet Air Force Base. Thus, it is also used for the C-5 and the C-135.

In 1985, an overlay was placed -n the cross-wind runway 14-32, (8620 by 150 ft), and a chip seal on the main runway 17R-35L, (12900 by 200 ft). There is also a third runway, 17L-35R (5500 by 100 ft).

Discussion of Problems

Faulting at the joints of the PCC pavement panels was evident. Also, there was surface cracking or crazing of the PCC pavement. While these are certainly problems that need to be dealt with to keep the airport safe, they do not necessarily mean poor performance of the approximately

40 yr-old pavement. The faulting would mean roughness, of course, and this would need to be corrected when it reached some level of severity. Likewise, the crazing could result in FOD problems if it advanced to the point that pieces of concrete scaled off. Of these, the faulting problem represents a loss in stability of the subbase or subgrade during thaw, and the crazing may be the result of freeze-thaw cycles at the pavement surface.

NORFOLK, NEBR. OFK (11-1) NOV 16-84 JEPPESEN

STEFAN MEM'L

N41 59.1 W097 26.1

Elev 1572' Var 08°E

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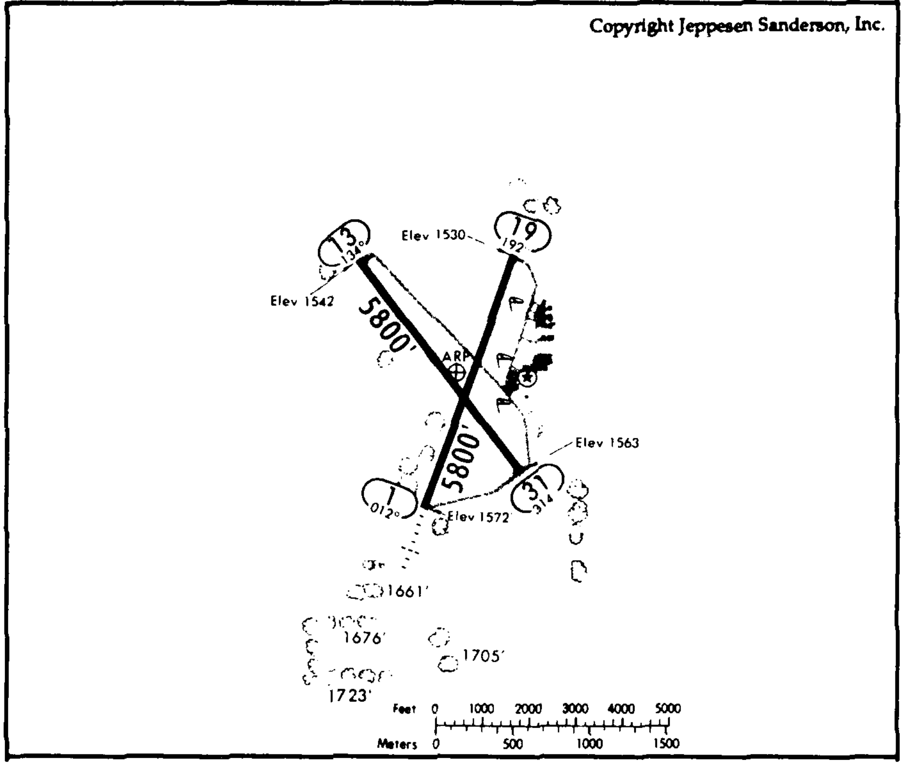


Site Visitation Group Visitation Date: 25 July 1985

W. Haas, Mich. Tech. Univ.; Robert E. Tannehill, Airport Manager, Karl Stefan Memorial Airport; Carl Rienstra, Nebraska Department of Aeronautics; Diane Hofer, Nebraska Department of Aeronautics.

Description of Airport FAA Region: ACE AAAE Region: NC

This airport was constructed in the 1940s as a military field for B-24's. Both runways (1-19 and 13-31) are asphalt concrete. The subgrade soil is sand over clay, so there is a tendency for high ground water levels.

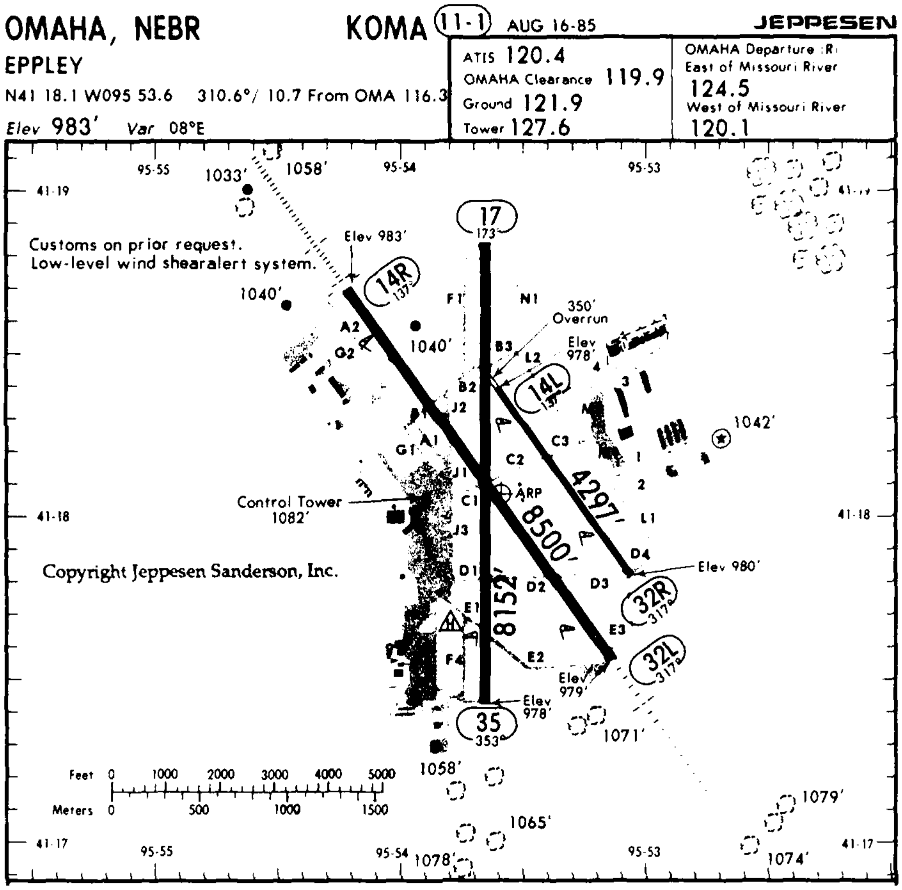
At the present time, Norfolk is served by two regional carriers, using small turbo-prop aircraft (10 to 12 passengers). This airport is also the base for two crop sprayers.

Discussion of Problems

Runway 1-19 has 11 in. of asphalt concrete over a very good base. However, this runway has very wide transverse cracks across the southernmost 1800 ft. These cracks are spaced about 100 ft apart. The runway width is 150 ft. A porous friction course was applied three years ago (1982), and joint repairs were made at that time. In one area on Runway 1, asphalt was bubbling up through previously non-existent cracks. There is evidence of a high groundwater table in the general area of Runway 1. A shallow excavation was so wet that construction equipment had difficulty even though the cut was on high ground. Also, a nearby taxiway had water over its surface during the spring of 1984. This had never happened before. It

should be pointed out that the winter of 1983-84 began with an early snow, thus the ground did not freeze, resulting in high infiltration.

A porous friction course was being applied to Runway 13-31 at the time of the site visit. Concern was expressed that the chips in this course would wear away too readily, thus creating debris and also degrading the effectiveness of the friction course. The aggregate used in the friction course was washed and somewhat rounded, thus they may not bond or adhere properly to the runway surface.



Site Visitation Group Visitation Date: 14 August 1985

W. Haas, Mich. Tech. Univ.; Milton R. Wuerth, Director of Operations, Eppley Airfield; Dave Osland, Project Engineer for Kirchman-Michael & Associates.

Description of Airport FAA Region: ACE AAAE Region: NC

The main runway (14R-32L) was overlaid in 1972, with a thickness of 7 in. at the centerline and 4 in. at the edges. The extra thickness at the center improved the cross-drainage of the runway. The overlay was grooved after a 90-day curing period.

Of special interest is the fact that the top 1.5 or 2 in. of this overlay contained asbestos fibers as an additive to the mix. This produced a very stable mix, with the result that the runway gave very good performance.

In 1978, category 2 runway lighting was installed, resulting in many saw cuts for cable runs. To cover the cuts, a 1.5 in. overlay was placed. This was subsequently grooved after a 90 day period.

Discussion of Problems

Reflective cracking occurred in a few months, and during the following winter, additional cracks occurred from one to four grooves away from the reflective crack. As the overlay was not well bonded to the previous pavement layer, large chunks of pavement broke loose and became a major FOD problem. Furthermore, as the cracking progressively developed, potholes were formed along much of the reflective cracking. These cavities were from a few to several inches wide, and from about one foot to eight feet in length. Thus, they become a major problem for repair as well,

requiring large quantities of material. These holes were filled with a combination of granite chips and crumb rubber asphalt.

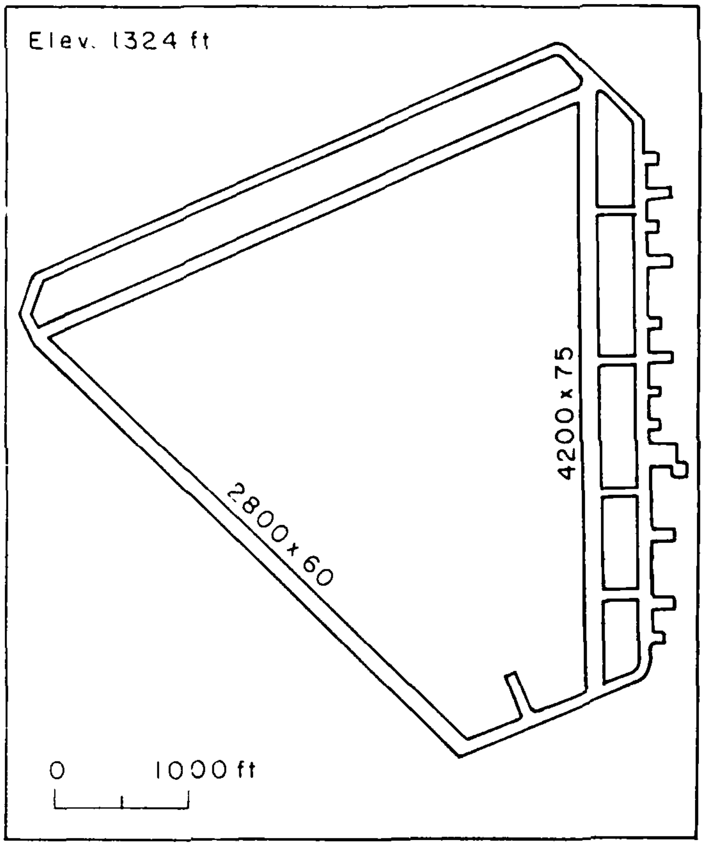
This major crack filling was required before the overlay was 6 months old, and has had to be continued as more of this type of failure progressively developed. It was probably due to the overlay being too thin to support grooving; the condition may have been aggravated by water freezing in the pavement grooves and in the interface between the overlay and the previous layer.

A combination of a low-stability mix and wear (rutting) has required that this pavement be regrooved in 1981 and again in 1983. The lack of stability in the mix is believed to have allowed the grooves to deform. The rutting has resulted in extra deep grooving being required to insure drainage.

Regrooving would have been required again in 1985. However, the condition of the pavement was such that reconstruction of the surface was required. This consists of milling off all the 1978 overlay plus a small part of the 1972 surface. The 1972 material thus exposed will be covered by a 5 in. overlay (3 in. base plus 2 in. finish course).

A special feature of the overlay is that the center 75 ft of the finish course will have plastic fibers incorporated in the mix. This fiber mix will also be used at some areas of heavy turning movements. The fibers used are 10 mm in length.

SCRIBNER, NEBRASKA
Scribner State Airfield



Site Visitation Group

Visitation Date: 25 July 1985

W. Haas, Mich. Tech. Univ.; Carl Rienstra, Nebraska Department of Aeronautics; Diane Hofer, Nebraska Department of Aeronautics.

Description of Airport

FAA Region: ACE

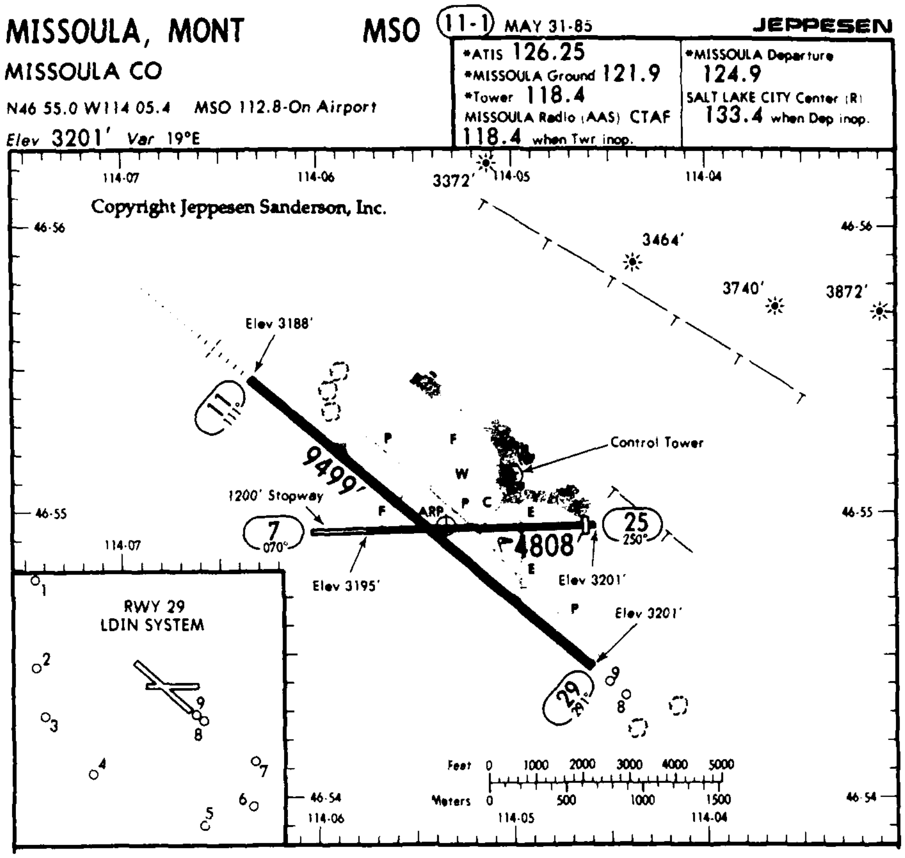
AAAE Region: NC

This airport was originally constructed in 1942 as a military training field. It consists of three runways in a triangular pattern. It is presently owned and maintained by the state of Nebraska. One runway and parallel taxiway have been closed, and the State is trying to reduce maintenance costs by partially closing, or "shortening," the other two runways. Costs are also reduced by the practice of maintaining less than the full width of the runways. Although the usage of this airport is light, it is the base for a crop-spraying operation which is very important to the surrounding agricultural area. Also, 16 small aircraft are based at the airport.

The PCC runways and taxiways are 9 in. thick, with aircraft parking areas, originally designed for B-24's, as much as 18 in. thick. The subgrade soil is considered to be well-drained, but it has a high clay content. No subbase was provided, as the PCC slabs were placed directly on the natural soil. Thus, with the lack of underdrainage, there is a potential frost problem. A surface drainage system was provided in the original construction.

Discussion of Problem

The State, as owner of the airport, is maintaining the pavements with a view toward protecting its capital investment and providing a safe airport. The slurry seal is being applied to the runways to seal the surface cracks that are forming in the original OCC pavement and to maintain friction on the surface. Joint repair was done before the slurry seal was applied.



<u>Site Visitation Group</u> Visitation Date: 25 June 1985

T.S. Vinson, I. Zomerman, USACRREL; R. Pankey, Director of Airports; B. Lower, Airport Superintendent.

<u>Description of Airport</u> FAA Region: ANM AAAE Region: NW

Runway 7-25 was originally constructed in 1942. The original section consists of 2 in. AC (P-401) over 10 in. of crushed aggregate base (P-209) over an E-7 subgrade soil. AC and crushed aggregate base was overlaid on the runway in 1957 and 1979. Runway 11-29 was constructed in 1969. The original section for 7000 ft of runway consists of 2 in. AC (P-401) over 10 in. of crushed base (P-209) over an E-7 subgrade soil. This was overlaid in 1975 with 3 to 4 in. of AC (P-401) over 12 in. of bituminous base course (P-201). Approximately 2500 ft of runway consists of 3 to 4 in. of AC (P-401) over 8 to 9 in. of bituminous base (P-201) over 18 in. of crushed aggregate base (P-209) over an E-7 subgrade soil. The taxiways and parking aprons were constructed between 1942 and 1977 and generally consist of 2 to 4 in. of AC (P-401) over 6 to 10 in. of crushed aggregate base (P-209) or 8 to 20 in. of bituminous base course (P-201) over the E-7 subgrade soil. The ramps consist of 10 in. thick PCC slab.

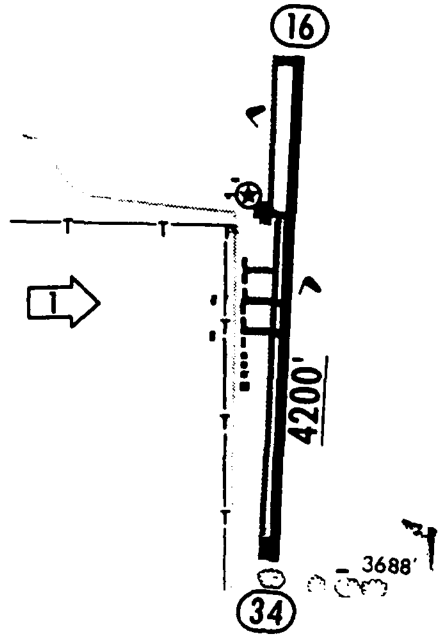
<u>Discussion of Problems</u>

In December 1984, very deep transverse cracks appeared on the runway (and out into the surrounding ground); the cracks may be related to an earthquake which occurred in October 1983 with an epicenter 200 miles away that caused the pavement to "roll." A PFC was used on the runway with very good performance; the maintenance manager believes the rate of ice melt is

much faster on the PFC. In an overlay presently under construction, a geotextile is being used to inhibit reflection cracking.

The runways have exhibited roughness in the winter to the extent that one runway was nearly closed. The roughness lasted about one month.

HAMILTON (Ravalli Co) 6S5
3638'. 46°15'N 114°07'W. Lights: Activate RL, VASI 16,34-122.8. Mgr: J. Reif, (406) 363-4737. Hrs. of opn: 0800-1900 Jun-Oct, 0800-1700 Nov-May. Fuel: 3,6,JetA. Ox 3. Repairs: MAME. Accom: T,L. UNICOM CTAF 122.8. 162°/39.3 NM-Missoula VORTAC.



Site Visitation Group

Visitation Date: 26 June 1985

T.S. Vinson and I. Zomerman, USACRREL; Joe Reif, Airport Manager; Harold Handke, Certification Safety-Inspector, FAA, Helena, MT; Tom Hanson, Principal, Professional Consultants, Inc., Missoula, MT; Jay Unrue, Superintendent, Ravalli County Road Dept.; Frank Williams, County Commissioner.

Description of Airport

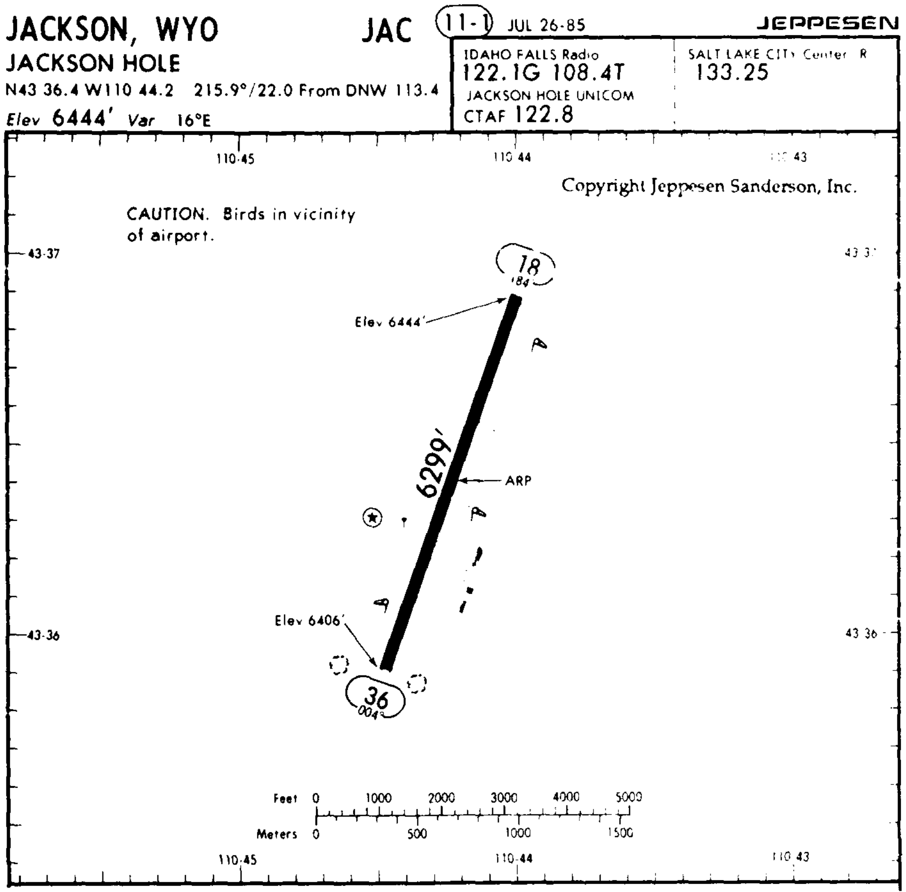
FAA Region: ANM

AAAE Region: NW

Runway 16-34 was originally paved in 1963. The structural section consisted of 1 in. AC over 18 in. gravel base. In 1980, a 1 in. double bituminous chip seal was placed on the runway bringing the total surface thickness to 2 in. Over much of the airport the base course is underlain by a silty clay layer which, in turn, is underlain by gravel. In the summer of 1983, 2300 ft of parallel taxiway and a 230x650 ft parking apron were constructed. The taxiway and apron consisted of 1 in. double bituminous chip seal (P-609[M]) over 9 in. aggregate base course (P-208) over the natural subgrade compacted to a depth of 6 in. to 95% standard proctor density (AASHTO T-99).

Discussion of Problems

Severe differential frost heave, estimated to be as great as 0.3 ft, occurred on Runway 16-34 in the winter of 1984-85 resulting in the closure of 2000 ft of the runway. "Bird baths" and differential heave occurred on the parallel taxiway during the same winter. The double bituminous surface treatment in the recently constructed parking apron "bleeds" during the summer. The airport manager sanded the area but the aircraft owners were upset owing to the excessive brake wear caused by the sand. A geotextile was placed beneath the aggregate base in the parking area and this area has not experienced differential heave. A geotextile was not used beneath the parallel taxiway.



Site Visitation Group

Visitation Date: 28 June 1985

T.S. Vinson, I. Zomerman, USACRREL; C. Lewis, Airport Manager; D. Johnson, Assistant Airport Manager.

Description of Airport

FAA Region: ANM

AAAE Region: NW

The airport came into existence in 1939 and was originally unpaved. In 1959, Runway 18-36 was widened to 100 ft. In 1975, the present structural section was constructed. The section consists of 3 in. AC (P-401) over 7 in. crushed aggregate base (P-209) over the compacted subgrade (P-152). The parallel taxiway consists of 4 in. AC (P-401) over 5 in. bituminous base course (P-201) over the compacted subgrade (P-152). In 1981, an approximate 1 in. (PFC) was added to the runway. In 1985, a rubberized seal coat was applied to the PFC.

Discussion of Problems

The PFC has performed very well and the fog seal recently applied to it has not blocked the pores. The fog seal was used to "blacken" the runway to improve the rate of snow and ice melting. The parking area near the terminal shows severe distress in many areas (in contrast to the runway and taxiway pavements). The distress may be related to their snow removal practice of stockpiling the snow on the upslope side of the apron resulting in subsurface meltwater beneath the apron in the spring. The overall very good condition of the runway is a testimonial to the airport manager's advocacy of continual maintenance.

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Vinson, Ted S.

Definition of research needs to address airport pavement distress in cold regions / by Ted S. Vinson, Richard L. Berg, Irene Zomerman and Wilbur Haas. Hanover, N.H.: U.S. Army Cold Regions Research and Engineering Laboratory; Springfield, Va.: available from National Technical Information Service, 1989.

v, 147 p., illus., 28 cm. (CRREL Report 89-10.)

Bibliography: p. 52.

1. Airfields. 2. Cold regions. 3. Frost action. 4. Pavements. 5. Surveys. I. Vinson, Ted S. II. Berg, Richard L. III. Zomerman, Irene. IV. Haas, Wilbur. V. United States Army. VI. Corps of Engineers. VII. Cold Regions Research and Engineering Laboratory. VIII. Series: CRREL Report 89-10.